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BETTERMENT WORK ON THE SANTA FE.

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PART I.—GENERAL.

Object.

During the past two or three years a remarkable work has been going on in the motive power department of the Santa Fe System. Starting with a systematic effort to improve the condition of the machinery and equipment, the centralization of manufactured material and the introduction of the individual effort method or bonus system at the Topeka locomotive repair shops, the "betterment work," as it is called, has gradually been extended throughout the motive power department over the entire system. The purpose of this article is, as briefly and clearly as possible, to consider the results which have thus far been accomplished and to trace the development of the work.

The betterment work was started in May, 1904, at the time of the machinists', boilermakers' and blacksmiths' strike. The objects of this work, in the order of their importance, were:

(1) To restore harmonious and cordial relations based on mutual respect and confidence between employer and employe.

(2) To improve the condition of the worker and give the company more reliable and trustworthy employes.

(3) To increase automatically and without fixed limit the pay of good men; this increase of pay depending on themselves and not on their immediate superiors.

(4) To increase the capacity of the shops without adding new equipment.

(5) To increase the reliability of the work turned out or the efficiency of the operations performed.

(6) To do all these things not only without cost to the railroad company, but with a marked reduction in its expenses.

The prime object, therefore, was to increase the efficiency of the mechanical department, although, as indicated by the last clause, it was expected that economy would follow as a natural result.

The betterment work has been carried on under the general direction of Mr. J. W. Kendrick, second vice-president, by Mr. Harrington Emerson, counselling engineer, in co-operation with the motive power department under Mr. A. Lovell, superintendent of motive power. The hearty co-operation of the accounting department under Mr. W. E. Bailey, general auditor, of the purchasing department under Mr. W. E. Hodges, general purchasing agent, and of the store department under Mr. N. M. Rice, general storekeeper, has materially assisted in making possible the remarkable results accomplished.

The Santa Fe System and the Organization of the Mechanical Department.

The Santa Fe System covers 8,500 miles and operates 45,347 cars, of which 44,204 are freight cars, 995 are passenger cars and 148 are miscellaneous. It has 1,633 locomotives.

The motive power department is in charge of Mr. A. Lovell, superintendent of motive power, and is divided into five mechanical divisions as follows:

(1) Eastern Grand—Chicago to Newton. Mechanical superintendent, W. F. Buck; 2,600 miles, 584 engines.

(2) Western Grand—Newton to Albuquerque and El Paso. Mechanical superintendent, M. J. Drury; 2,650 miles, 430 engines.

(3) Coast Lines—Albuquerque to San Francisco. Mechanical superintendent, S. L. Bean; 1,800 miles, 367 engines.

(4) Gulf Lines—Shawnee, Okla., to Galveston. Mechanical superintendent, P. T. Dunlop; 1,450 miles, 252 engines.

(5) Topeka Shops—General repair and manufacturing shop of the system. Superintendent of shops, John Purcell.

The map on the following page will give those who are not familiar with the Santa Fe an idea of its great extent and the territory covered by the various divisions of the mechanical department.

The Topeka shops are the largest on the system, the superintendent of shops reporting directly to the superintendent of motive power. The other shops are under the master mechanics upon whose division they are located.

Outline of the Betterment Work.

It was believed that the objects stated above could best be accomplished by increased supervision and special reward to the workmen. Increased supervision was to be aided by a more frequent and prompt tabulation of the various performance records and by special expert investigations of every operation, as to the man, machine methods and material, with consequent planning to eliminate wastes of every kind. The work was limited to the maintenance accounts and to locomotive operation in its various phases, repairs, roundhouse work, supplies, fuel consumption, failures, lessening of delays in the shops, adjustment of repair activity to traffic needs, etc. This extensive work was, of course, taken up gradually and locally, and as will be shown later is only in partial operation at the present time.

From May, 1904, to October, 1905, the work was confined to the Topeka shops, and first consisted in the rebuilding and remodeling of many machines, in the concentration of manufacture of materials, especially of tools at the Topeka shops, and in the starting and establishing of the individual effort reward system.

The betterment work was extended to different parts of the system and to include various features as follows:

Oil-burning on locomotives, March, 1905.
General tool account for the system, August, 1905.
Topeka roundhouse, September, 1905.
Albuquerque shops, November, 1905.
Raton and Winslow, January, 1906.
Shopton (Illinois Division), January, 1906.
San Bernardino shops, Coast Lines, February, 1906.
General roundhouse work, April, 1906.
Cleburne shops, May, 1906.
Car work on the system, August, 1906.

In addition power house conditions are being investigated and improved. The matter of engine equipments is being studied and abuses corrected. Engine performances on different divisions and on the system as a whole are being follower

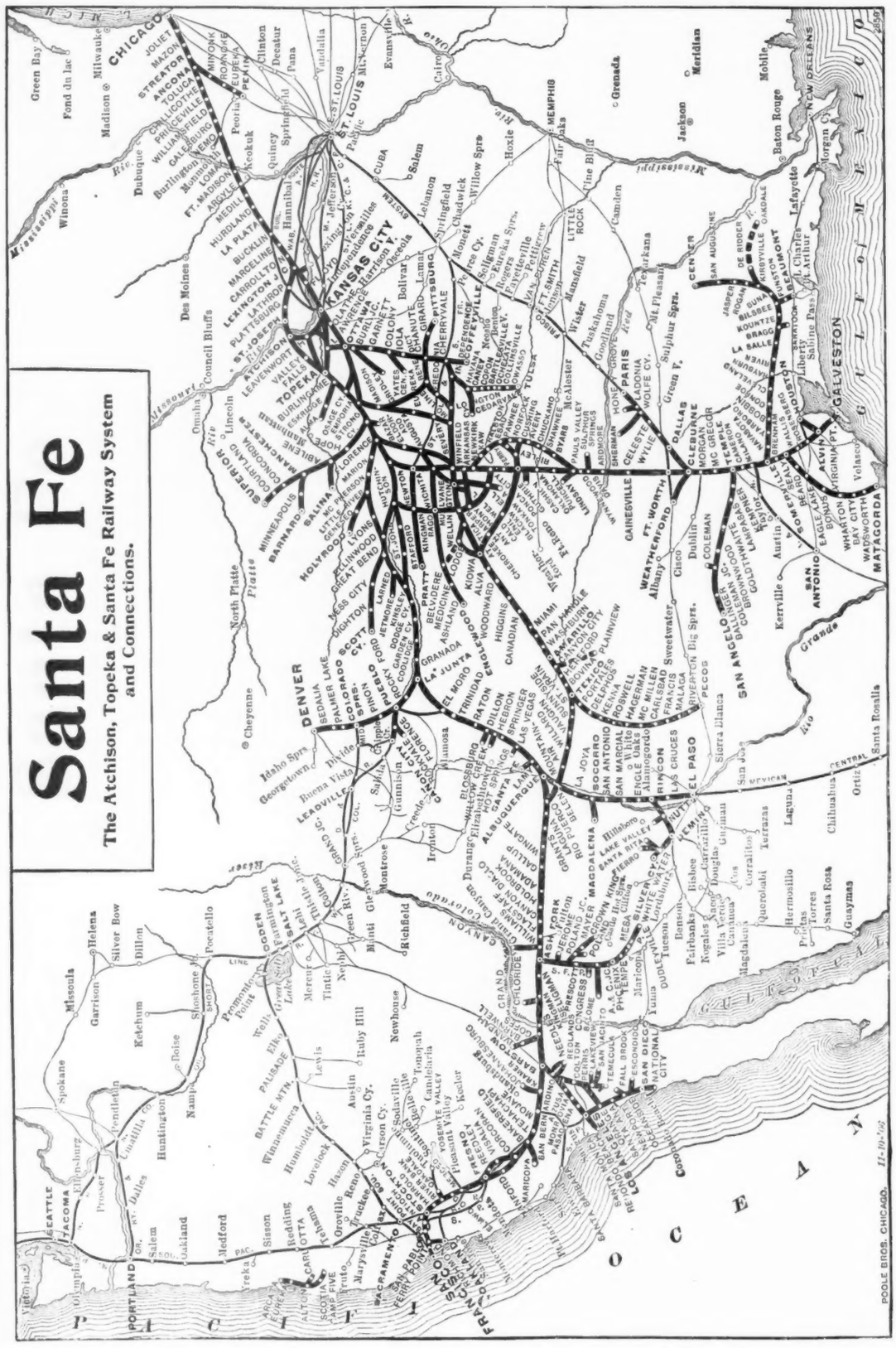


FIG. 1.—MAP OF THE SANTA FE SYSTEM.

up by graphical records which show at a glance the exact condition as compared to previous records. The same thing is being done with the mechanical department payrolls.

General Results.

Thus far the betterment work on the Santa Fe has materially assisted in restoring harmony between the employer and employe, and in greatly increasing the efficiency and reliability of the worker. His wages have been increased on an average of from 10 to 20 per cent.

As has been stated, the prime object of the betterment work was to increase the efficiency of the mechanical department, and while it was expected that economies would naturally result, the following study, based upon the president's reports for the fiscal years of 1905 and 1906, while, of course, only approximate, shows conclusively the value of the betterment work in this respect; this, too, in spite of the fact that much of the betterment work on the system as a whole was not started until the fiscal year of 1906 was more than half gone

and has not even as yet been fully installed. In order to check the results and possibly bring them out more clearly the figures in the president's reports for 1905 and 1906 will be examined from several viewpoints.

* * * * * * * * * * *

The president's reports cover the fiscal year beginning July 1st and ending June 30th.

SAVINGS FIGURED ON AN ENGINE BASIS.

	1904-5.	1905-6.
Total number of engines June 30th	1,454	1,633
Reduction in cost per engine, including all renewals, distributed and adjusted charges		$1,064.07
Total economy on 1,633 engines	$1,737,626	
Average engines in service	1,447	1,550
Reduction in cost per engine as above		$918.15
Total economy	$1,423,132	
Reduction in cost, actual charges for repairs only to account 12, engines, and account 17, tools and shop machinery		$795.49
Total economy	$1,233,009	

This last figure is based on engines actually in service, and with the exception of maintenance of shop machinery and tools does not include renewals, supervision, boiler service or other adjusted and distributed expenses.

* * * * * * * *

SAVINGS FIGURED ON A MILEAGE BASIS.

	1904-5.	1905-6.
Engine mileage	40,727,636	45,694,524
Increase 1905-6 over 1904-5		4,966,888
Per cent. of increase		12.2

Direct reduction of cost per engine mile, not including renewals or distributed accounts:

Labor	$0.0225
Material	$0.0068
Total account 12	$0.0293
Account 17	$0.00386
Total reduction	$0.03316

Had the cost per mile been as high as in 1904-5 the additional cost would have been:

For account 12	$1,338,850
For account 17	176,809
	$1,515,659

The actual cost of supervision increased from $367,555.94 in 1904 to $446,287.54 in 1905-6. This was an actual increase of $78,731.60, but reduced to a basis of mileage the increase would be only $33,813.95 greater than it would have been if the cost per mile had been the same for 1905-6 as for 1904-5. The miscellaneous expenses, which also include the expenses of power house and water service operation, were reduced from $817,055.79 in 1904-5 to $563,536.94 in 1905-6. The actual decrease in this item, therefore, amounted to $253,518.85, although if reduced to a mileage basis the reduction would amount to $353,218.67, part of which was due to betterment work. The saving based upon the cost per mile would, therefore, agree quite closely with the results derived from the total cost per engine.

* * * * * * * *

Assuming that the repairs are proportional to the fuel used, the above figures may again be checked:

	1904-5.	1905-6.
Coal used, tons	1,910,845	2,101,906
Fuel oil used, tons	525,005	604,340

Equating the fuel oil on a basis of 60 lbs. of oil to 100 lbs. of coal, the tons of fuel burned in 1904-5 would be 2,784,245, as compared to 3,108,000 for 1905-6. On a fuel basis of 1904-5 the locomotive repairs for 1905-6 should have been $1,308,650 greater, and the tool account would have been $155,400 greater, making a total saving of $1,654,050 if we assume that the greater cost of supervision is offset by the saving in the general expense account due to the betterment work.

* * * * * * * *

On the Santa Fe a road unit is equal to the engine mileage multiplied by the weight on drivers in pounds divided by one hundred million. The cost for 1905-6 based upon the cost per road unit for 1904-5 would be:

	1904-5.	1905-6.
Total road units	47,855	56,301
Road unit cost	$106	$78
Saving on basis of 1904-5:		
Locomotive repairs	$1,618,091	
Tool account	204,936	
Total	$1,823,027	

* * * * * * * *

Checking the figures on the basis of number of tons on drivers, we find the following:

	1904-5.	1905-6.
Tons on drivers	85,421	100,054
Saving on basis of 1904-5:		
Locomotive repairs	$1,591,859	
Tool account	202,109	
Total	$1,793,968	

* * * * * * * *

The store department by a careful and systematic effort over the entire system reclaimed and put into use a large amount of material, and effected a considerable saving in the figures of 1906 as compared with the previous year. Nevertheless, the saving due to the advice and methods of the betterment department, put largely into effect through the regular mechanical officials, could probably on the most conservative basis be placed at a million and a quarter dollars. This is a remarkable showing, especially as a large part of the work was started too late in the year to have any appreciable effect upon the annual report.

General Methods.

In undertaking a work as large and far-reaching as that of the betterment work on the Santa Fe there are a few general principles which must be kept ever in mind and be closely adhered to. The men in charge of such work must overlook the situation from a broad viewpoint, and must not be misled by details.

Such success as has been attained is due largely to the inculcation of principles and the modification of practice to agree with principles. A pertinent illustration is the treatise entitled "Shop Betterment and the Individual Effort Method of Profit Sharing," which was prepared by Mr. H. Emerson and with the approval of Mr. J. W. Kendrick and Mr. A. Lovell distributed among the employes of the mechanical department of the Santa Fe, and was reprinted on page 61 of our February, 1906, issue. The words placed at both the beginning and end of this treatise are worthy of repetition: "Fairness not favoritism, efficiency not drudgery, and individuality not subserviency."

Mr. Emerson lays special stress on the importance of having records and not reports to indicate what is actually being accomplished, and all his assistants are instructed to base their work on records, and if these are lacking to begin work by making them. A report is usually based upon exceptionally good showings that have been made, but a record to be truly valuable should be based upon the average work that is being done. The exceptionally good record has a value, of course, in that it gives an ideal point which we should strive to reach.

To avoid errors and to give the greatest possible authority and weight to the figures used four principles are followed:

First—Official figures only, if in existence, are used. If there are no official figures, use the most reliable records obtainable until official figures can be supplied.

Second—As comprehensive figures as possible are used.

Third—Each statement should cover not a single month, but the average of at least a year. This is done by averaging in each month a whole year of records. For instance, instead of saying this is a record of December, 1906, the statement takes this form: This is the rate or monthly average for the year ending December 31, 1906.

Fourth—Use an attained practical minimum as a standard to which to work.

The accompanying engine performance diagrams (Figs. 2 and 3) illustrate nicely the third and fourth clauses as stated above. The record for each month is averaged with the eleven preceding months. No spasmodic or special effort for a single

month will greatly change the direction of these lines. Only a steady improvement extending over a considerable period of time will materially affect their direction. The differences due to changes of seasons or accidents are also eliminated, and the lines show clearly the actual tendencies. The repairs are based on the amount of fuel burned, thus eliminating differences due to grades, seasons and special conditions, as these features affect similarly both the fuel and the repairs. As a locomotive is a machine for converting the energy of coal into work at the draw bar, it is evident that work done should vary directly with coal burned. Repairs should vary with work done. Therefore dollars of repair, per ton of coal, gives us a unit of comparison in which variation of grades, speed, etc., can be ignored. The coal used on mountain divisions is greater than that used on the plains. The repairs are also greater, but the work done is also greater and the ratio of dollars of repairs to tons of fuel remains surprisingly constant.

This ratio does not, of course, show as strikingly as it

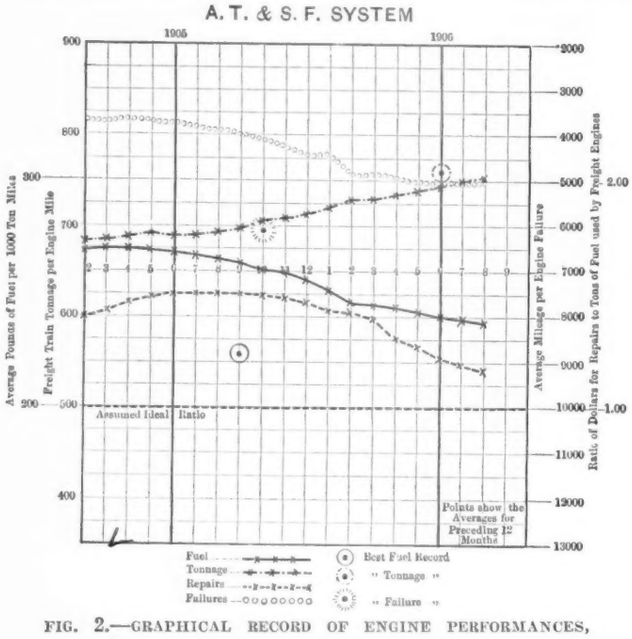

A. T. & S. F. SYSTEM
1905
1906
Average Pounds of Fuel per 1000 Ton Miles
Freight Train Tonnage per Engine Mile
Average Mileage per Engine Failure
Ratio of Dollars for Repairs to Tons of Fuel used by Freight Engines
Assumed Ideal Ratio
Points show the Averages for Preceding 12 Months
Fuel
Tonnage
Repairs
Failures
Best Fuel Record
" Tonnage "
" Failure "

FIG. 2.—GRAPHICAL RECORD OF ENGINE PERFORMANCES, A., T. & S. F. SYSTEM.

would if otherwise plotted, the great reduction made in the cost of repairs, since due to careful and systematic efforts the amount of fuel burned per 1,000 ton miles has been decreased considerably during the past year. As may be seen, however, the cost of repairs has been reduced in even a greater ratio. It is interesting to note that as the matter of locomotive repairs has been given greater attention the number of engine failures has gradually but surely decreased; the average freight train tonnage per engine mile has steadily increased, and the average pounds of fuel per thousand ton miles has steadily decreased. Three points will be noticed on the diagrams, one showing the best fuel record, one the best tonnage record, and one the best record for miles run per engine failure. These points show the best records for any one month during the time covered by the diagram and furnish ideal points to work too. The assumed ideal ratio for the cost of repairs to tons of fuel used by freight engines is $1 to each ton of fuel. This record has actually been accomplished on some few of the other railroads, and on some divisions on the Santa Fe the line shown on the diagram has already been passed and there appears to be little question that the Santa Fe System as a whole will eventually reach this point. The first diagram is for the Santa Fe System as a whole, and the second (Fig. 3) is for the Eastern Grand Division. It will be seen that on the Eastern Grand Division the above standard for repairs has not only been attained, but that for a considerable period the cost of repairs, per ton of fuel used, has been less than the ideal. Diagrams similar to the ones shown are drawn up for each district and sent out every month. Each master mechanic is therefore stimulated to censure fuel waste and to lessen repair waste.

This same method applied to other records makes it possible intelligently to analyze conditions and to locate and correct the weak points.

As various facts indicating wastes or opportunities of improvement are reported to Mr. Emerson's office, all the conditions are investigated and new methods are, as the case may require, considered in conference with the general auditor, with the general purchasing agent, with the superintendent of motive power, with the general statistician, with the general storekeeper, with the superintendent of the shops and the mechanical superintendents, or general managers. When an agreement has been reached and there is need for final authoritative action, the desired changes are submitted to the second vice-president for final approval. This adopts and incorporates the modifications due to special work into the regular departments effected by these modifications.

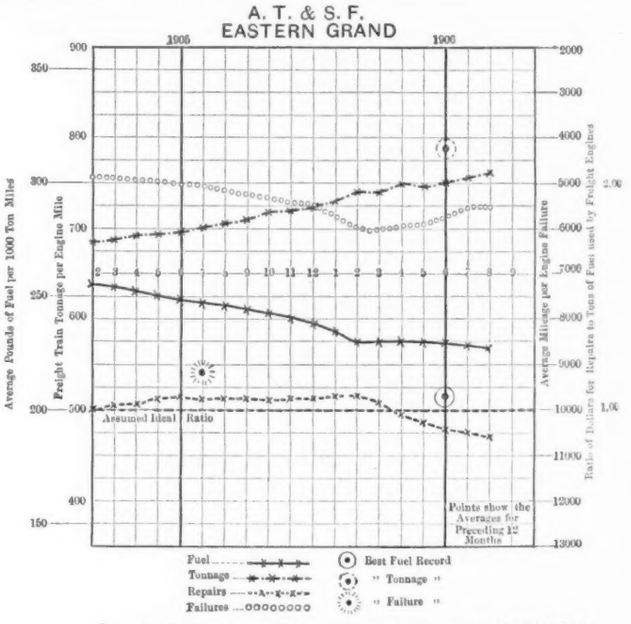


FIG. 3.—GRAPHICAL RECORD OF ENGINE PERFORMANCES, EASTERN GRAND DIVISION.

As examples of this co-operative work the following are cited:

(1) All mechanical pay rolls and distribution are reported daily by the mechanical auditors.

(2) Specifications as to many supplies have been adopted by the general purchasing agent.

(3) The superintendent of motive power has approved recommendations for standardizing tools and engine parts, and other innumerable recommendations.

(4) The general statistician has put into effect a monthly report of locomotive performance, and has given valuable compilations and comparisons from other railroad systems.

(5) The general storekeeper has always immediately adapted his own department procedures and records to the often annoying experimental changes, and he has directed all division storekeepers to co-operate in every possible way.

(6) The superintendent of the Topeka shops, while never abdicating his position as head of these shops, has after conference and mutual agreement put into effect locomotive, gang and machine schedules, has himself introduced the new methods into the blacksmith and other departments, etc.

(7) The mechanical superintendents have co-operated as to roundhouse and car work and as to the smaller shops.

(8) General managers have seconded efforts and carried out recommendations as to power house betterments, and as to fuel and supplies for locomotives.

Records of payrolls, engine repairs, engine mileage, engine failures, engine tonnage, engine fuel consumption, engine supplies, of tool and machinery repairs, of car deten-

tions and repairs are sent regularly to Mr. Emerson's office, and there tablulated and graphed so as to show promptly and in the plainest manner the general tendency over the entire system, giving as it were in a single glance a comprehensive "bird's eye" view of maintenance, shop, engine, car, fuel and supply conditions of the system as well as of each individual point.

The method as a whole has been to collect facts, to investigate and evolve remedies, to adapt them to the experience of regular officials, to entrust the application of remedies to the regular officials, and occasionally and only temporarily lending a hand. The regular graphed records permit of keeping in constant touch with what is going on.

When vacancies have occurred and promotion was being considered these graphical records of individual performance have been carefully considered by the higher officials. Three of the four mechanical superintendents have been promoted to their present positions since January, 1906, and in each case the promotion was made on records previously tabulated in graphical form. The records had, in fact, selected these men for promotion before vacancies occurred:

Organization of the Betterment Department.

Mr. Harrington Emerson, counselling engineer, has general charge of the betterment department, and is also the local resident for Topeka shops and the Eastern Grand Division problems. Mr. Emerson is assisted by Mr. Clive Hastings, formerly of the Northern Pacific Railway. The work carried on in Mr. Emerson's office is of a general character. Methods are evolved in co-operation with the auditing department to secure freely and promptly records of payroll accounts, distribution, etc. The reports from the entire system as to tools, locomotive output, cost of repairs, fuel and tonnage performances, failures, mechanical payrolls, etc., are tabulated and graphed, and mechanical superintendents are advised of the results on their divisions.

The special men directly connected with the betterment work and reporting to Mr. Emerson are: Mr. H. W. Jacobs, formerly of the Burlington and the Union Pacific. He is territorially in charge of all betterment work on the Coast Lines and functionally in charge of the tool and machinery betterments for the system. His title is engineer of shop methods and tools, and to his experience and skill are largely due the betterments of shop machinery, the standardization of tools, etc., with consequent reductions of cost. At San Bernardino, California, marked reductions in expense and marked increase in output followed the introduction of betterment methods under Mr. Jacobs' directions.

Mr. H. E. Muchnic assists Mr. Jacobs at Topeka in connection with the tool and machinery betterments.

Mr. J. E. Epler, formerly of the Burlington, the Delaware, Lackawanna & Western and the Vanderbilt Lines, is territorially in charge of betterment work on the Gulf Lines and functionally in charge of all car work.

Mr. S. D. I. Emerson is in charge of the betterment work on the Western Grand Division, and with him is associated Mr. W. J. Power, formerly of the Union Pacific. Mr. Emerson and Mr. Power, before going to the Western Grand Division, were in charge of the time studies and bonus schedules and of the introduction of individual effort methods at Topeka.

Mr. J. F. Whiteford, formerly of the Burlington and the Union Pacific, is in charge of all betterment work as applied to roundhouses.

Mr. Curtis B. Goode is in charge of power house economies.

Mr. Thomas W. Neely is in charge of oil-burning economies.

Mr. F. L. Hutchins, formerly of the Boston & Maine, is in charge of records and graphs.

Mr. G. S. S. Playfair was at Shopton and in charge of road unit records.

Mr. E. K. Wennerlund is general assistant on the A., T. & S. F. Proper.

Under Mr. Jacobs, Mr. R. Emerson has special charge of account 25, supplies to locomotives.

In addition each of the above has his own assistants, the total number of men directly engaged on this work in October being 31.

PART II.—DEVELOPMENT AND SPECIFIC RESULTS.

Belting.

The first work undertaken by the betterment department, May to October, 1905, was confined to the Topeka shops, and consisted in improving the efficiency of the shops and establishing the individual effort reward system. One of the first things considered in connection with improving the efficiency of the machine tools was that of belting. Investigation developed the fact that the time lost on the various machines due to belt failures was a very serious item, and the expense of maintaining the belting, which was given about the same attention as in the average railroad shop, was excessive.

As may be seen by the accompanying diagram, Fig. 4, the belting expense at the Topeka shops alone amounted to about $1,000 per month, with 300 failures, when the work was undertaken in 1904. The installation and maintenance of belting was placed in the hands of a specialist, with instructions to prevent failures, not remedy them, and only the best quality of material was used for repairs and renewals. An inventory was made of every belt in the shop, and an accurate record kept of its performance on a form similar to that shown in Fig. 5.

Knowing that the best practice indicated that the cost of

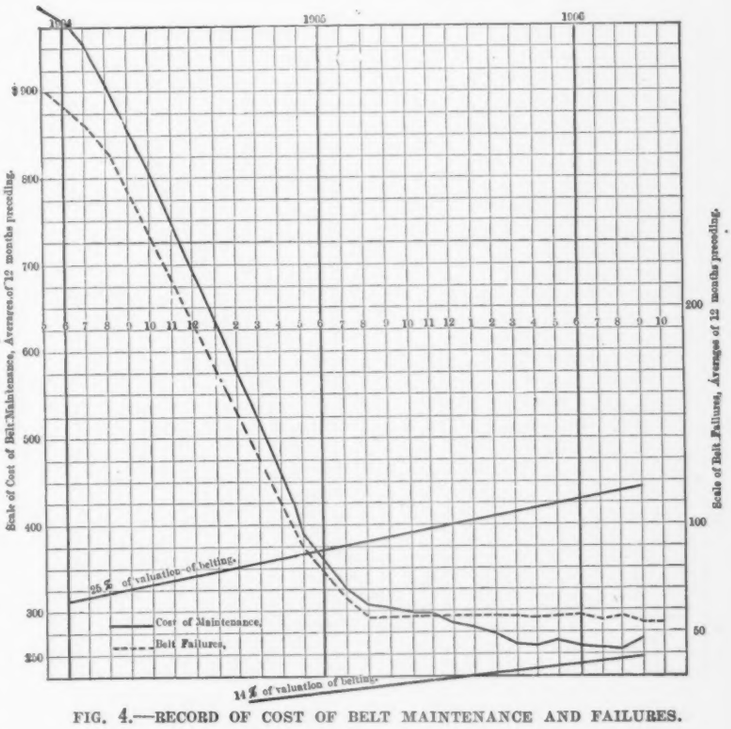

1904
1905
1906
Scale of Cost of Belt-Maintenance, Averages of 12 months preceding.
Scale of Belt Failures, Averages of 12 months preceding.
25 % of valuation of belting.
14 % of valuation of belting.
Cost of Maintenance.
Belt Failures.

FIG. 4.—RECORD OF COST OF BELT MAINTENANCE AND FAILURES.

maintaining belts, including labor, supplies and belting, should yearly average about 14 per cent. of the first cost, and taking into consideration the fact that much of the belting was not of the best grade, had been in operation for years and was running under unsatisfactory conditions, it was decided to set the ideal to work too, at 25 per cent., with the intention of finally reaching 14 per cent. as conditions were improved. The diagram clearly shows the results accomplished. The expense has been decreased from $1,000 to about $275 per month, the failures from 300 to about 55 per month.

A belt room, about 10 by 35 ft., was fitted up with a complete outfit for repairing belts. The belt foreman also has charge of oiling and of abrasive wheels.

For general service the Jackson or machine lace is used. When a belt is first installed a take up piece 6 ins. long is

inserted. As the belt stretches this piece may readily be removed by withdrawing the two rawhide pins and a shorter piece inserted to take its place. Various lengths of these take up pieces are kept in stock (Fig. 6), and it is a matter of only a few minutes to put in a shorter piece and properly adjust the belt.

The fact that the most expensive material is often the cheapest is strikingly illustrated in this instance, and the following specifications for belting on the Santa Fe are of interest in this connection:

Width :
Thickness :
Length :

BELT RECORD CARD

Shop :
Machine :
Position :

Requisition issued : / Requisition filled :	Purchased from : / Cost :	Scrapped : / Scrap Value :
Max. Speed :		
Max. Power :	INTERRUPTIONS	REMARKS
Max. Tension :		
Splices :		

DATES	MAINTENANCE	DATES	CAUSE
	Put on by		
	Tightened to lbs. tension		
	" "		
	" "		
	" "		

FIG. 5.—BELT RECORD CARD.

SPECIFICATIONS FOR BELTING.

Belting must be of the best oak tan, first quality leather, strictly short lap stock, cut within 18 ins. of the center of the hide and no piece running over 4 ft. 6 ins. long; tanned under the long time process, absolutely free from acids or other ingredients for quickening the tannage or increasing the weight.

Belting must be of uniform thickness and width, and will be inspected at destination. Any belting showing uneven thickness or width or flabby soft spots will be rejected and must be replaced at once, without cost to the Railroad Company.

All belts must have a tensile strength of not less than 4,200 lbs. per sq. in., in either the leather or the splice, and show elongation of not over 12.5 per cent. in 2 ins., 1 in. either side of the break, or less than 8 per cent. elongation at breaking strain.

Any double, triple or quadruple belt which starts to crack or give way between the layers comprising the belt before reaching a tensile strength of 2,500 lbs. per sq. in. will be rejected.

All belting will be furnished in three grades, as below:

Heavy, weighing 17 to 19 oz. per sq. ft.
Medium, weighing 15½ to 16 oz. per sq. ft.
Light, weighing not less than 14 oz. per sq. ft.

The above weights are guaranteed to be no more than 10 to 13 per cent. above the actual weights of the leather after treatment by gasoline, or other process, to remove any stuffing or filling.

All belting must bear the manufacturers' brand and name on every 10 ft. of belting.

All belting, when received at destination, will be laid out flat to its full length, and must lay in a straight line from end to end, both edges of the belt lying flat upon the floor.

GUARANTY.

If the belt as received does not in every particular comply with the above specifications it will be rejected, and replaced by the seller without expense to the Railroad Company.

It is further guaranteed that the belting will run practically straight and not stretch, to trouble where shafting and pulleys are right and care has been used in placing it upon them.

To more clearly indicate the systematic way in which the belting question was handled, thus showing the careful investigation and treatment of details by the betterment department and giving a general idea of the methods pursued by them, the following extracts are reproduced from the "Rules and Instructions for Belt Repairmen" compiled by Mr. Emerson for use on the Santa Fe:

Cement Splices.—The first thing to be noted in making a cement splice is to see that the pieces put together are of about the same grade, width and thickness, and that the splices line in the same direction in the same belt. Splices should be made of the length given in the table:

Width of Belt.	Length of Splice.
1 in.	5 ins.
2 ins.	5 ins.
3 ins.	6 ins.
4 ins.	6 ins.
5 ins.	7 ins.
6 ins.	8 ins.
7 ins.	8 ins.
8 ins.	9 ins.
9 ins. to 18 ins.	Same length as width.
Over 18 ins.	18 ins.

Splices should be worked down to a perfectly smooth, even surface, square with the edge of the belt both at the point and back. Care should be taken that the splice is no thicker than the rest of the belt. If the splice is thick the belt will not run even. Square both ends of the splice from the same edge of the belt. Work on a perfectly smooth, flat surface. After dressing the ends for the splice, place them together on a board 1 in. longer and ½ in. wider than the splice. Place the edges from which the splices are squared in a perfectly straight line. Tack the belt to a board, just back of the splice. Open the splice and spread on hot glue, place another board on top of the splice and clamp tightly with hand clamps or in a press. (An old letter press makes an excellent belt press.) If a press is used, ten minutes is long enough to keep pressure on the belt, but if hand clamps are used they must be left on for three or four hours. In either case the belt should not be put under tension for at least five hours after gluing. Paper placed between the boards and the belt will prevent the belt from becoming glued to the boards.

Greasy belts should be cleaned in gasoline before attempting to cement them. Any grease in the belts or glue is liable to cause the splice to fail. No rivets, wire pegs, or any other fastenings aside from cement should be used in splicing belts. Ordinary furniture or patternmaker's glue is satisfactory for belting.

Width of Belting.—A pulley should be 25 per cent. wider than the belt running on it. This rule should be followed as closely as possible, and especially with cone pulleys.

Tension and Thickness of Belts.—Belts should have a tension when at rest of about 100 lbs. per sq. in. of width of good double belting. If not practical to measure the tension on the belt, make the fit length 1 in. per 10 ft. less than the tape-measured length over the pulleys. A steel tape should be used. Great care should be taken to prevent the running of too tight belts and consequent burning of bearings.

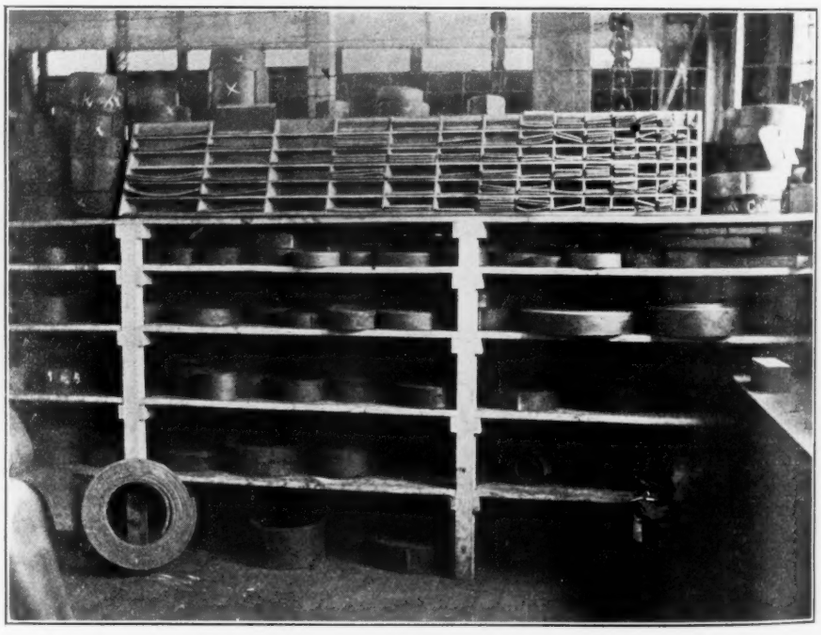


FIG. 6.—CORNER OF BELT ROOM SHOWING STOCK OF "TAKE UP" PIECES AND BELTING.

Double belts should not be run on pulleys less than 6 in. in diameter, and triple belts on pulleys less than 20 in. in diameter. Belts should sag onto the pulleys and not away from them. Very short drives (belts under 20 ft. long) should be avoided. Whenever possible, run up-and-down belts on a slant, so that the belt will sage onto the pulley.

For each horsepower to be transmitted allow 80 sq. ft. of double belt to pass over the pulleys per minute; allow 160 sq. ft. of single belt, or 1,000 lineal ft. of double 1 in. belt, or 2,000 lineal ft. of single belt.

Kind of Lace to Use.—For general service, the Jackson lace should be used, and new belts should have a 6-in. take-up piece put in them to permit the tightening of the belt by putting in a shorter piece, and thus avoiding the need of taking the entire belt down. Belts with Jackson lace should have a take-up piece in them at all times. Pieces should be kept in stock in sufficient numbers to avoid the necessity of making one in an emergency. The lengths should be 6, 5, 4, 3, 2, and 1 ins.

The Kerr lace may be used to hold very thick belts and small feed belts which the Jackson lace will not accommodate.

The rawhide lace may be found by trial to give better service on

SIZES	Symbol
½" x 1" x 8"	C 102
⅝" x 1¼" x 8½"	C 103
⅝" x 1½" x 8½"	C 104
¾" x 1½" x 9"	C 105
¾" x 1¾" x 9½"	C 106
⅞" x 1½" x 10"	C 107
1" x 2" x 12"	C 108
1½" x 2½" x 18"	C 109

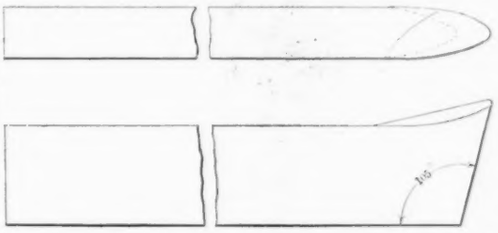


FIG. 7.—HIGH SPEED STEEL LATHE SIDE ROUGHING TOOL AND SYMBOL NUMBERS FOR ORDERING.

some woodworking machines than either the Jackson or Kerr laces, but it is generally best to make the belt endless, if neither Kerr nor Jackson lace give satisfaction.

Endless Belts.—All machines furnished with any means of taking up the stretch should have endless belts. Large overhead drive belts (over 6 ins. wide) should be made endless as soon as the stretch is taken out. It is not advisable to make new endless belts at installation on account of the stretching. Woodworking machinery having belts which do not require too frequent tightening will run better with endless than laced belts. Side and bottom head belts on planers, matchers, etc., should be run endless.

Cleaning and Oiling.—Belts which have become too greasy and dirty should be cleaned in gasoline, then scraped and wiped with waste. In dry, dusty places it is well to brush them occasionally with a broom or stiff brush.

No rosin or belt dope should be used except fish oil and tallow

	SIZE
T 102	¼" x 1" x 8"
T 103	⅜" x 1¼" x 8"
T 105	⅜" x 1½" x 9"

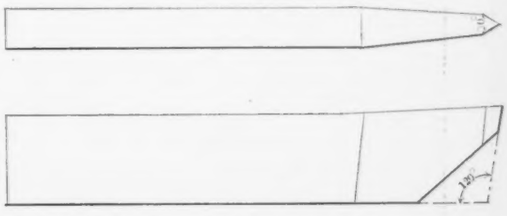


FIG. 8.—STANDARD STRAIGHT THREADING TOOL AND SYMBOL NUMBERS FOR ORDERING.

mixed in equal parts. Apply hot with a brush when the belt is running, or dip the belt in the dope tank, then dry and wipe off any grease which may have hardened on the belt. If applied while running, care should be taken not to get too much on the belt or it will cause it to slip. When properly applied, the mixture of fish oil and tallow will make the belt pull better than any of the commercial dressings. No mineral oil should be allowed to come in contact with the belt. New belts should be treated with fish oil and tallow before using, and any belt which becomes dry, hard and glossy in service should have an application of the dressing. This is especially true of belts in blacksmith shops. The oil will check to some extent the evil effects of the smoke, sulphur gases and dirt, and the life of the belt will thereby be lengthened.

Inspection of Belts.—Close attention should be given to the condition of the belting to prevent damage to it and delay to the machines. Such delays can be reduced to a minimum by making repairs as soon as weakness develops. Main drive and section belts should be watched very closely, since a failure of one of them may shut down a number of machines for a considerable length of time.

Operation of Belts.—The most essential thing to the successful operation of belts is that pulleys and shafting be properly lined and in good repair. It is bad practice to throw a pulley out of line to favor a bad belt. Belts should be run with the hair side to the face of the pulley. Run the belts so that the outside point of the splice trails. This will avoid opening of the splice by the action of the air. Belts should never be run twisted or cross-stepped on cones.

Keep the pulley clean and avoid having mineral oil or grease come in contact with the belts. If hard grease or dirt is allowed to pile up in the corners of the cones, so as to form a fillet, the belt will be very likely to climb, turn over or twist. In turning the faces of the cones a clearance should be cut in the corners. A drive pulley carrying a shifting belt should never have a crown. In throwing belts onto the pulleys, first put the belt on the driven pulley (loose, if there is one) and then run it onto the driving pulley. Avoid accidents by stopping the motor or engine, and then run the belt on while starting slowly.

Care should be taken never to run a belt off a moving pulley onto some part of the shafting or machinery on which it might catch. If necessary to cut a belt down, care should be taken not to waste the leather.

A belt should never be dampened in order to open the splice. An awl should be used, gradually scratching or ripping the splice apart.

It is good practice to remove the tension from the belts by lifting idlers, running off of pulleys, or removing from the machine, when convenient, at quitting time. All cone and other machine belts should be run off of the pulleys at quitting time on Saturdays.

Tools and Machinery.

The next step taken was to improve the efficiency of the shop machinery and tools. Each machine tool was carefully examined, and in many instances it was found necessary to redesign and strengthen certain parts in order to properly adapt the tools for the use of high-speed steel and the improved methods which it was proposed to install. Cast iron pinions and gears were in many instances replaced with steel. Cone feed pulleys were increased in size to accommodate heavier feeds. Cone pulleys were redesigned to take larger

FIG. 9.—PART OF TOOL RACK IN TOPEKA STOREHOUSE CONTAINING LATHE, PLANER, AND BORING TOOLS FOR SHIPMENT.

belts and transmit more power. The countershafting was speeded up. These changes were under the direction of Mr. H. W. Jacobs and in line with those described by him in an extensive article on "High-Speed Steel in Railroad Shops," page 338 of the September, 1904, issue of this journal. This matter of railroad shop machine tool equipment is considered at length in the third number of a series of articles by Mr. Jacobs on "Organization and Economy in the Railroad Machine Shop" in the November issue of *The Engineering Magazine*. Mr. Jacob's series of articles began in the September issue of that magazine, and will be concluded in the January issue.

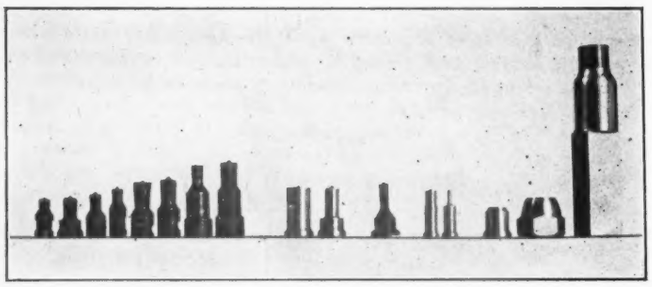


FIG. 12.—OLD AND NEW PUNCHES COMPARED.

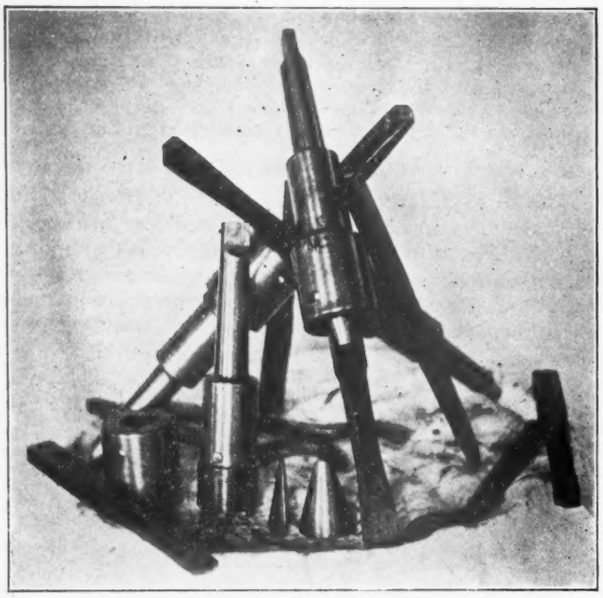


FIG. 14.—STANDARD CHUCK FOR HIGH SPEED FLAT DRILLS

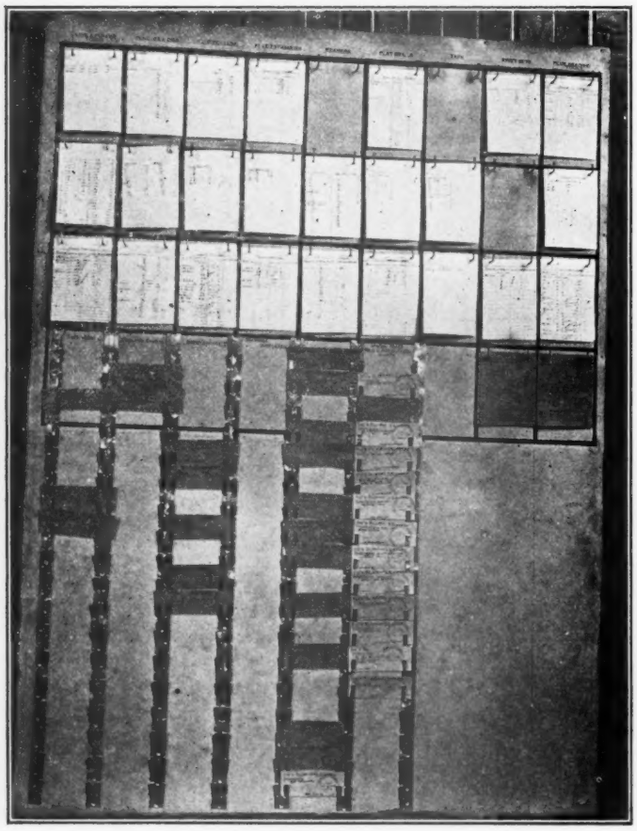


FIG. 17.—BOARD SHOWING TOOLS ORDERED, IN STOCK AND ON REQUISITION.

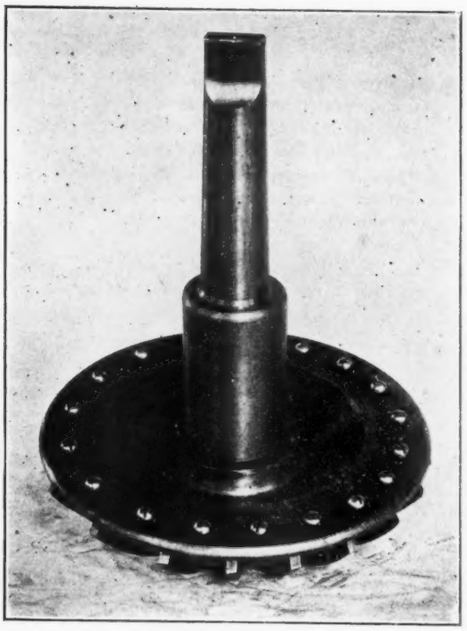


FIG. 13.—STANDARD BALL JOINT REAMER.

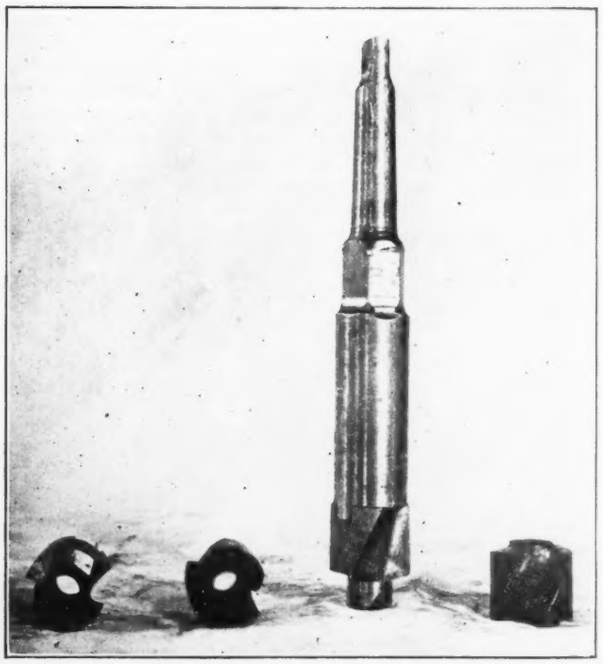


FIG. 15.—HIGH SPEED FLUE SHEET REAMER.

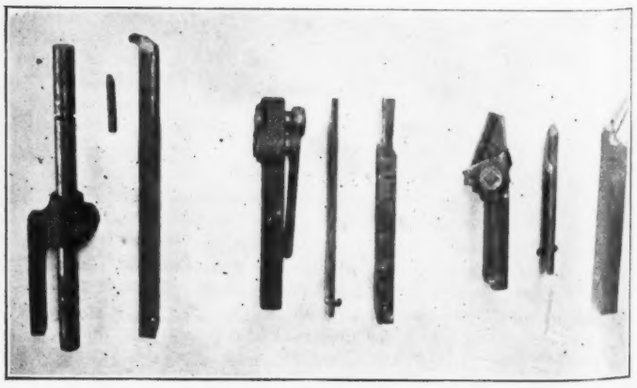


FIG. 16.—TOOL HOLDERS AND TOOLS COMPARED TO SOLID TOOLS.

At the same time standard shapes and standard material for cutting tools were selected by Mr. Jacobs to replace the large miscellaneous collection of cutting tools of all kinds, makes, shapes and qualities of material. At the present time practically all the cutting tools for the system are made at the Topeka shops. Each shop is furnished with a series of blue prints, similar to those shown in Figs. 7 and 8, showing the various tools, and from these necessary supplies are ordered by symbol number. Shaping and tempering the tools in accordance with the best practice and manufacturing them in large quantities at the Topeka shops has not only greatly increased their efficiency, but has also effected a very considerable saving.

It is, of course, impossible to go into this question in detail in this article, but a few typical examples of what has been accomplished will be considered. Fig. 9 shows part of a rack in the storehouse at Topeka containing the lathe, planer and boring tools and tool holders in stock and ready for shipment to outside points.

The punches and dies for the system have been standardized, as shown by the accompanying illustrations (Figs. 10, 11 and 12). Punches 5/8 in. and less in diameter fit a standard sleeve (Fig. 11), making it possible to use the same coupling as for the larger sizes and yet greatly reduce the cost of these smaller sizes, since they may be made from a much smaller stock than would be required if the sleeve was not used. Fig. 12 shows at the left a miscellaneous collection of old punches, then two of the larger standard punches, an old-type punch of the smaller size, compared to two of the new standard smaller size punches and sleeve and a standard coupling.

Flue rollers, flue expanders, reamers, flat drills, taps, rivet sets, flue beading tools, etc., have also been standardized. Ball joint reamers, Fig. 13, used for steam pipe joints, etc.,

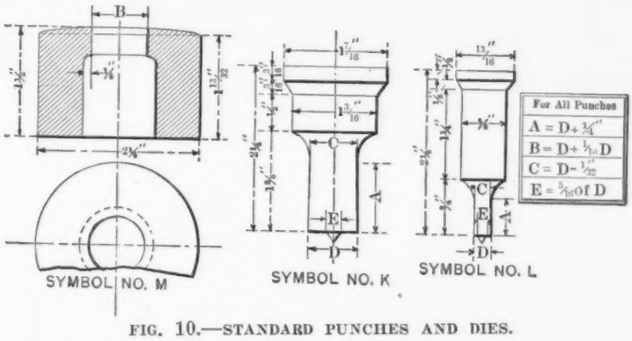


FIG. 10.—STANDARD PUNCHES AND DIES.

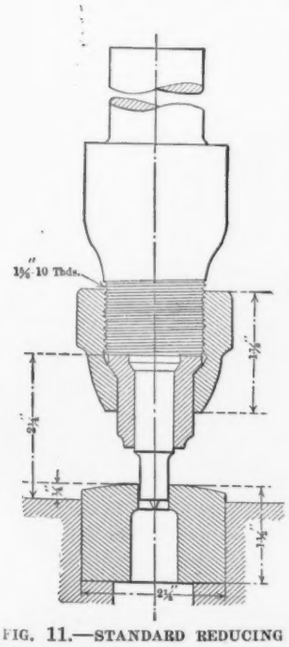


FIG. 11.—STANDARD REDUCING COUPLING AND PUNCH.

have been reduced to two standard sizes, thus doing away with a large number of miscellaneous reamers.

A standard chuck for flat high-speed drills is shown in detail in Fig. 14, and these, as well as the drills to fit them, are manufactured for the system in large quantities at the Topeka shops.

The flue sheet reamer shown in Fig. 15 has a high-speed cutter on a soft steel arbor. At the Topeka shops these reamers are reaming holes at a rate exceeding one per minute. The cutter may be easily and cheaply replaced if broken or if it requires regrinding, and standard sizes may be maintained at a comparatively small cost.

High-speed tool steel is very expensive, and it was found that by designing and using proper tool holders the amount of this steel which would be required could be reduced to a minimum. One of the illustrations (Fig. 16) shows several of these tool holders with the small tools as compared to the old type solid tools.

The board shown in Fig. 17 is kept in the office of the tool department at Topeka, and shows just how many of each type of tool is on hand in the storehouse; how many are being made on shop orders, and how many have been ordered on requisition from outside points. The lower part of the board is adapted to show just what special tools and jigs have been ordered and where they are being made in the shop. This arrangement enables the man in charge to keep a careful check on the manufacture and shipment of tools, and see that requisitions are filled as promptly as possible. A record is kept of the tools ordered and used at the various shops, and it is thus possible to correct any abuse and prevent an excessive number from being carried at the different points.

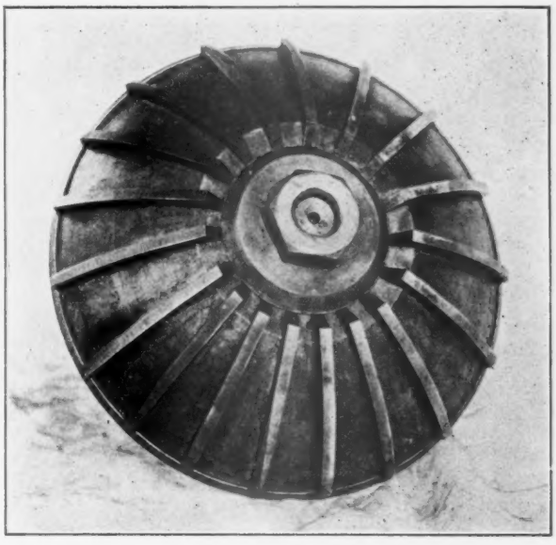


FIG. 13a.—ANOTHER VIEW OF STD. BALL JOINT REAMER.

Special chucks and devices for facilitating the chucking of work and holding it more firmly, in order to make it possible to take more or heavier cuts, were devised, and these have been instrumental in greatly reducing the cost of manufacture. The method of milling piston valve bushings, shown in Fig. 18, is a very good illustration of this. Formerly only one hole was milled at a time, and the bushing was adjusted by hand for each set of holes. By the new method four holes are milled at one time, and the mandrel which supports the bushing is revolved by a worm and gear as shown.

Another good illustration is that of milling eccentric straps, Fig. 19. The eccentric straps are first clamped to the cast iron jig and the long bolts are then adjusted, as shown, preventing the straps from shifting, and making it possible to take as heavy cuts as may be necessary.

These are typical instances of improvements made in the machine shop proper. A number of interesting tools and devices were also noticed in the erecting shop, which, while possibly not all new, play an important part in increasing the output and reducing its cost. Space permits the mention of only two or three typical examples.

The pneumatic air drum hoist, Fig 20, makes it possible to raise an air drum for less than one-tenth of the cost under former conditions.

A pneumatic hammer for removing frame or other bolts is shown in Fig. 21. This is less than 12 in. high, and may be used in places where it is impossible to use a sledge. After being placed in position the lower lever is turned, forcing the plunger against the bolt. Then by quickly operating the upper handle a series of heavy blows drives the bolt out. This was devised and patented by Mr. A. Parfitt, boiler shop foreman.

Two other tools devised by Mr. Parfitt are shown in Figs. 22 and 23. The first is a portable hydro-pneumatic bushing extractor used largely in connection with piston valve bushings, and capable of exerting a pressure of 1,500 lbs. per sq in. The other is a portable hydro-pneumatic punch for use in the boiler shop.

A very considerable saving has been made due to improving the efficiency and reducing the cost of maintenance of pneumatic tools. Every Saturday all of these tools are turned in and carefully examined, repaired and oiled by a man in charge of this work. As in the matter of belts, the aim is to prevent failures and keep the tools in first-class condition all the time.

Although the prime object was to improve the efficiency of the tools and machinery, it has resulted in a marked improvement in economy as indicated by the diagrams, Figs. 24 and 25; Fig. 24 shows what has been accomplished in reducing the tool and machinery account on the Santa Fe System. This, of course, includes all the expenses in connection with the maintenance of the machinery and tools, including the

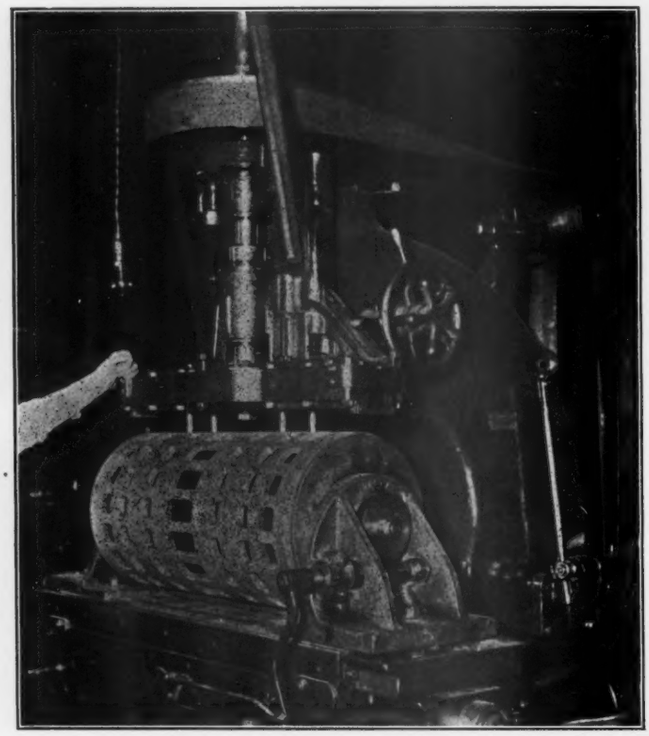


FIG. 18.—IMPROVED METHOD OF MILLING PISTON VALVE BUSHINGS.

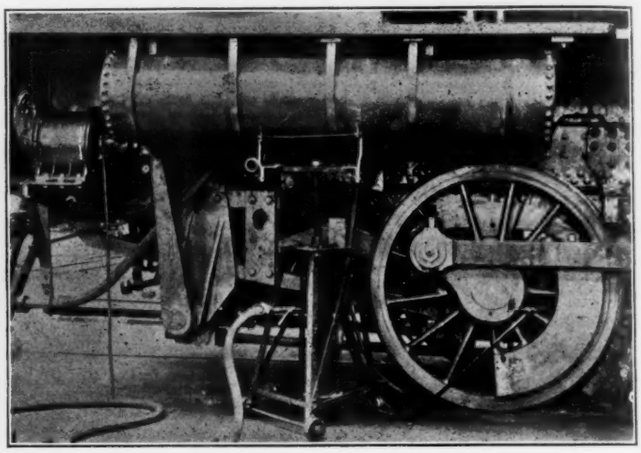


FIG. 20.—PNEUMATIC AIR DRUM HOIST.

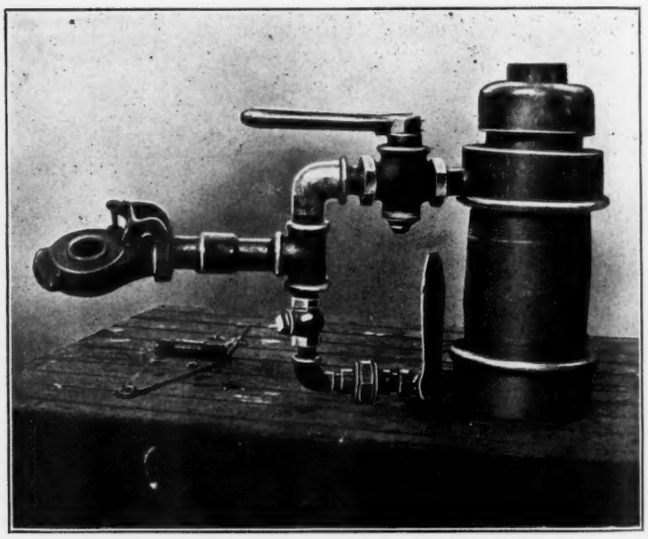


FIG. 21.—PNEUMATIC HAMMER FOR REMOVING FRAME BOLTS.

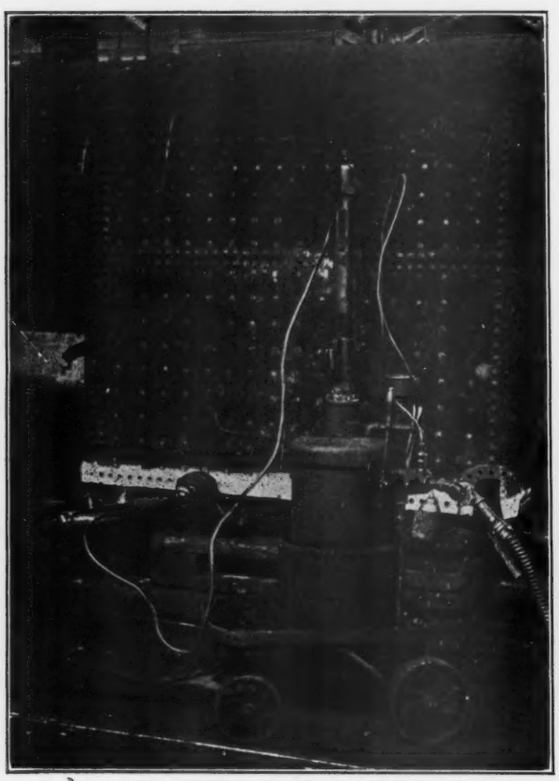


FIG. 23.—PORTABLE HYDRO-PNEUMATIC PUNCH.

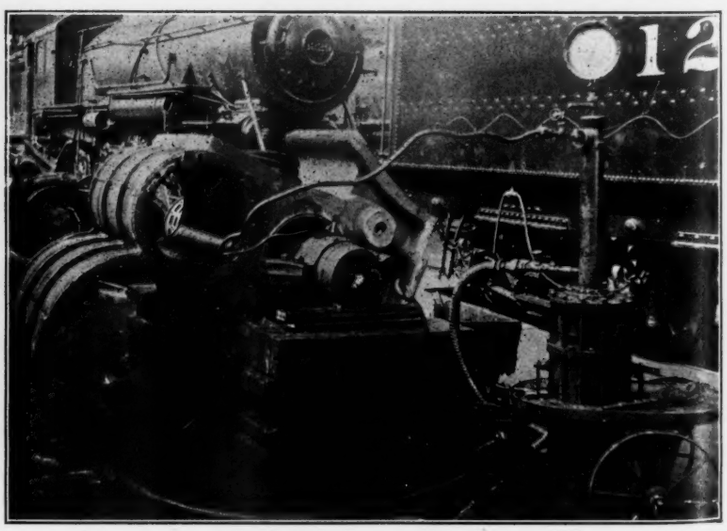


FIG. 22.—HYDRO-PNEUMATIC PISTON VALVE BUSHING EXTRACTOR.

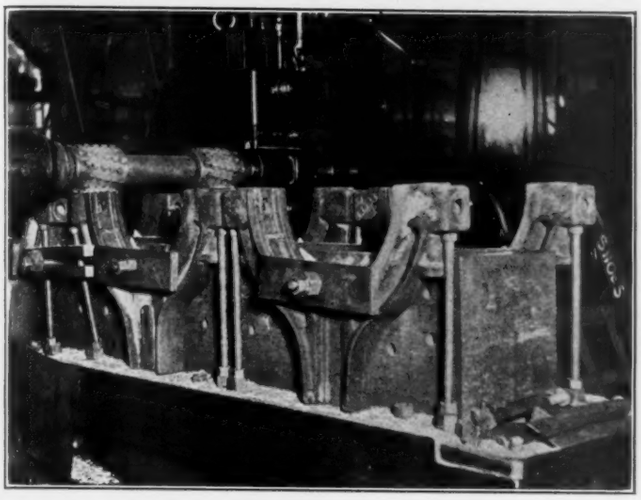


FIG. 19.—MILLING ECCENTRIC STRAPS.

belting, shafting, etc. The total cost is on a different scale from the labor and material cost in order that the diagram may not be too large. The lines marked "allotment for total cost," "allotment for material cost" and "allotment for labor cost" are the ideal points which it is desired to attain. These ideal points are not laid down arbitrarily, but are based on results which it is known are possible of attainment. Fig. 25 is for the Topeka shops. It was at this point that the work was started and has received the greatest amount of attention.

Diagrams similar to these are drawn up for each division on the system, and it is thus possible to follow this matter very closely. Each master mechanic has a fair and definite allotment, within which he is expected to keep. Every month each shop must send in on a form similar to that shown in Fig. 26 the cost for the maintenance of tools and machinery during the month. Separating and subdividing the various items in the account makes it possible to locate and correct

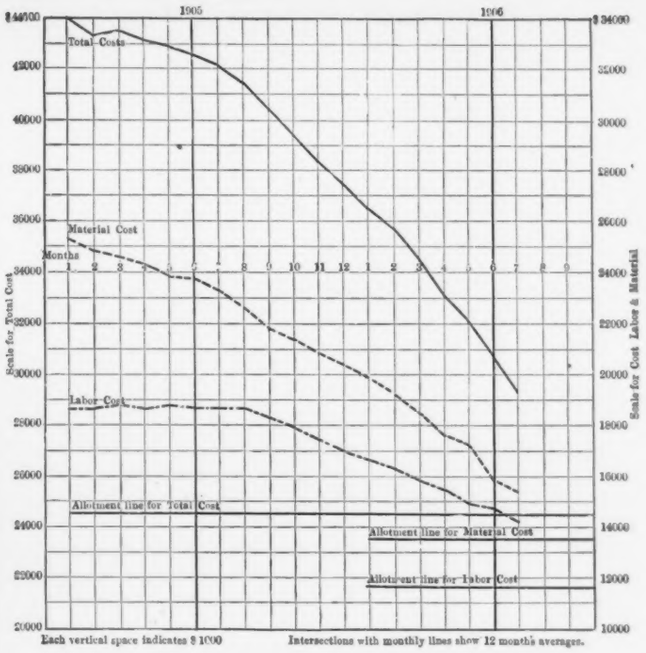


FIG. 24.—GRAPHICAL RECORD OF COST OF MAINTENANCE OF TOOLS AND MACHINERY ON THE SANTA FE SYSTEM.

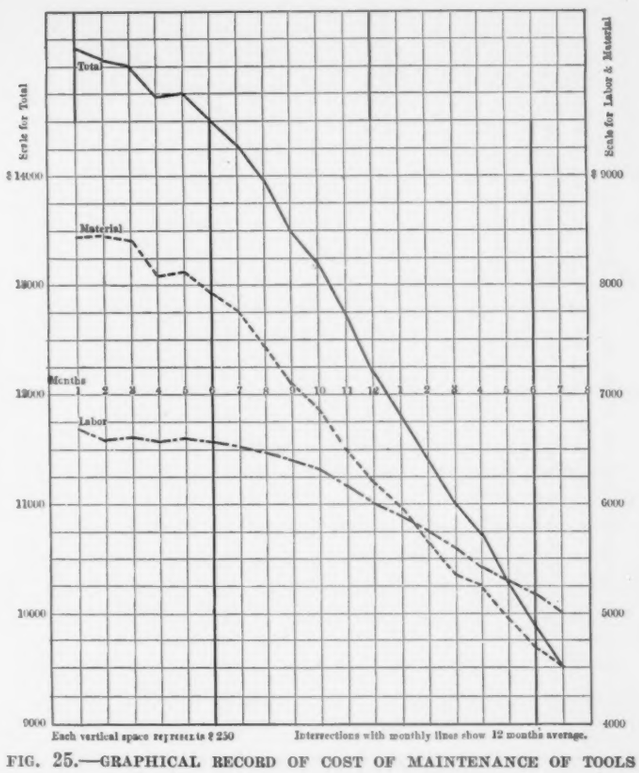


FIG. 25.—GRAPHICAL RECORD OF COST OF MAINTENANCE OF TOOLS AND MACHINERY AT THE TOPEKA SHOPS.

CHARGES TO TOOLS AND MACHINERY ACCOUNTS.

AT _____ SHOPS, DURING _____, 190__

	SHOPS	SETTING UP NEW MACHINERY 0	REPAIRS TO MACHINERY, FIXTURES AND SHAFTING 1	MAKING NEW TOOLS 2	REPAIRS TO TOOLS, INCLUDING DRESSING 3	COST OF ISSUING TOOLS 4	REPAIRS TO AIR LINE AND AIR TOOLS 5	ABRASIVE WHEELS 6	CARE OF BELTS AND OILING 7	REPAIRS TO ELECTRICAL MACHINERY 8	OTHER THAN FOREGOING 9	TOTAL
17-A	Machine Shop. 11											
17-B	Erecting Shop. 12											
17-C	Boiler Shop. 13											
17-D	Blacksmith Shop. 14											
17-E	Tin Shop. 15											
17-F	Brass and Air Room. 16											
17-G	Tool Room. 17											
17-H	Water Service. 18											
17-I	Pattern Shop. 19											
17-K	Car Machine Shop. 20											
17-L	Loco. Carpt. Shop. 21											
17-M	Wheel and Axle Shop. 22											
17-N	Power Plant. 23											
17-O	Miscellaneous. 24											
	TOTAL											

DATE. _____ FOREMAN

FIG. 26.—FORM USED IN CONNECTION WITH TOOL AND MACHINERY ACCOUNTS.

weak spots or abuses.

In September, 1904, the expense for the system was $45-125.10 per month. In April, 1906, it had fallen to $24,921.25 per month, or a little less than the "allotment for total cost" of $25,000 per month.

This result was accomplished largely by special efforts at Topeka, Albuquerque and San Bernardino, the total expense for tools and machinery at these three points amounting to 65 per cent. of the total for the system in January, 1905. This reduction was made in spite of the fact that the efficiency was very greatly increased by introducing better tools and by strengthening and considerably increasing the capacity of the machinery and equipment.

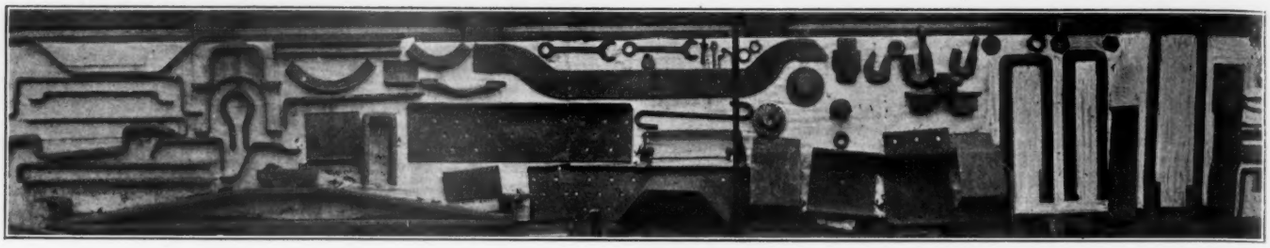


FIG. 30.—EXAMPLES OF WORK DONE ON FORGING MACHINES AND BULLDOZERS AT TOPEKA.

Centralization of Manufactured Material and Extension of Standards.

At the same time that the efficiency of the tools and machinery was being improved a movement was made to standardize, as far as possible, the various locomotive parts and do all the manufacturing for the system at Topeka. At the present time all manufactured and machined material is furnished by the Topeka shops. In many instances it is, of course, impossible to finish a piece entirely, but as much machine work as possible is done on it in order to reduce to a minimum the work to be done at the outside shops. Fig. 27 is the first sheet of a circular giving a list of locomotive parts manu-

List of Locomotive parts and Tools that in future will be manufactured and machined at Topeka, either complete or partially finished as stated below:

Bull Rings	Bored and faced, leaving outside diameter rough.
Blower elbows	Finished complete.
Crosshead pins	Centered, faced and threaded.
Cylinder heads	Finished complete.
Crossheads	" "
Crank pin collars	" "
Crank pins	Finished except fit.
Chafing irons	Finished complete.
Cylinders	Finished except saddle.
Drawbar carry irons	Complete.
Double cones (dry pipe T Heads)	Finished complete.
Driving boxes	Finished except boring brass and facing hub.
Engine bolts	Centered, turned for thread and threaded.
Engine truck boxes	Finished complete.

FIG. 27.—PARTIAL LIST OF PARTS MANUFACTURED AT TOPEKA.

factured at Topeka, and will give an idea of the extent to which this work is carried.

All turned bolts are to be made at Topeka. These bolts, of various lengths, are turned to standard sizes and placed in stock. Standard reamers are to be furnished each shop, and with each reamer are standard collars, so that the same reamer will ream holes to fit any one of several standard bolts, depending on the collar that is placed upon it. The reamers and collars are frequently checked with standards, and when worn are returned to Topeka for repairs.

Standard knuckle pin hole reamers with standard gauges, for the different classes of engines, are to be furnished to each shop and the large roundhouses. The reamers in each set vary from the standard size to ⅛ in. above by thirty-seconds. When a pin needs replacing the hole is reamed to the nearest size and a standard knuckle pin of a corresponding size, completely finished, is taken from stock.

Manufacturing all material at one point has many advantages; not only are the parts turned out much cheaper, better and more certain to be standard, but it is possible to use to advantage many special machines and devices which if placed in a smaller shop would lie idle the greater part of the time, thus making a very heavy surcharge on any of the work they might do. The work can, of course, be done with fewer machines at a central point than if it was being done at several points on the system.

The finished material storehouse platform at Topeka is

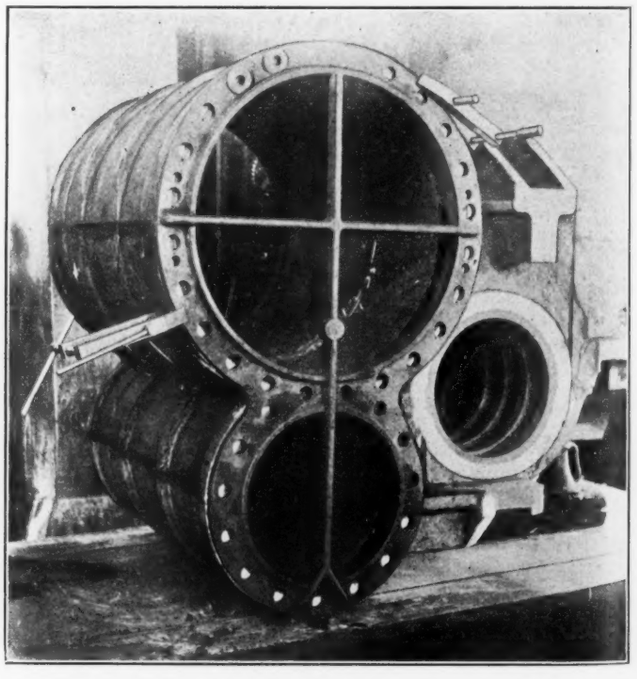


FIG. 29.—TEMPLATE FOR DRILLING COMPOUND CYLINDER.

shown in Fig. 28. With the store department in close cooperation with the mechanical department it is possible to keep an ample supply of finished material at the various repair plants, and by so doing it is, of course, possible to pass the engines through the shop for repairs and get them back in service in a minimum amount of time. This policy has been carried to such an extent at Topeka that even fireboxes for certain classes and cylinders are carried in stock ready to be placed on an engine as soon as it comes into the shop.

A considerable improvement was effected by checking over the patterns and reducing the amount of material allowed for finish where it was excessive. In some instances it was found advisable to change the grade or kind of material to facilitate machining or to give better results in service.

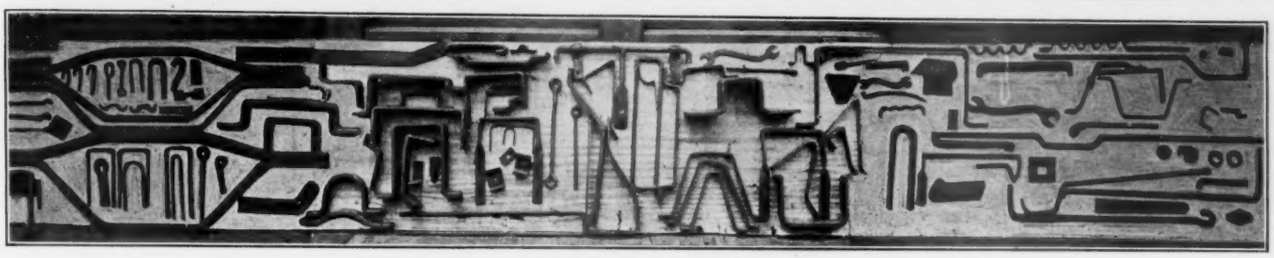


FIG. 30.—EXAMPLES OF WORK DONE ON FORGING MACHINES AND BULLDOZERS AT TOPEKA.

One noticeable feature at the Topeka shops is the large number of templets and jigs used. A templet for drilling holes in a compound cylinder for cylinder head studs is shown in Fig. 29. The equipment of templets and jigs for work of this kind is so complete that it is possible to drill all the holes in a cylinder casting without laying out a single one. In a small shop where parts are turned out at long intervals a complete equipment of such templets and jigs would, of course, be out of the question, but by concentrating work of this kind at one point they can be used to very great advantage.

In no department is the manufacturing activity more evident than in the blacksmith shop. One of the photographs (Fig. 30) shows a number of parts made by dies and formers used in connection with the bulldozers and forging machines. There are about 200 sets of these dies and formers, part of which are shown in Fig. 31.

FIG. 31.—SOME OF THE DIES AND FORMERS USED WITH THE FORGING MACHINES AND BULLDOZERS AT TOPEKA.

A very interesting and simple tool in this shop is one for making brakeshoe keys, devised and patented by Mr. George Fraser, the foreman. Part of the device (Fig. 32) is used in connection with a bulldozer, and forges two keys at one time from ¾-in. round scrap iron. The keys are then cut apart and sheared to shape by a special attachment used on an ordinary shear, as shown in Fig. 33. These brake shoe keys can be turned out by these tools at the rate of two or three thousand per day at an insignificant cost compared to the methods formerly used.

Individual Effort Method or Bonus System.

A general description of this system and its advantages is presented on page 61 of our February, 1906, issue. This article, entitled "Shop Betterment and the Individual Effort

FIG. 28.—FINISHED MATERIAL PLATFORM, TOPEKA STOREHOUSE.

Method of Profit Sharing," was prepared by Mr. Harrington Emerson and by direction of Mr. Lovell, superintendent of motive power was distributed among the motive power employes of the Santa Fe System. An understanding of this system and what may be accomplished by its use may probably best be conveyed by presenting an abstract of this treatise, although it is suggested that our readers will find the article itself much more comprehensive and complete.

The employer, of course, wishes to reduce the cost of output to a minimum in order to meet competition. The employe, on the other hand, wishes as high wages as he can get. A system by which the employer could pay higher wages than the average and at the same time cheapen the cost of output would be an ideal one. That this may be accomplished is indicated by a series of examples presented by Mr. Emerson. The first one is a cost statement of a large machine shop in an Eastern State, and is as follows:

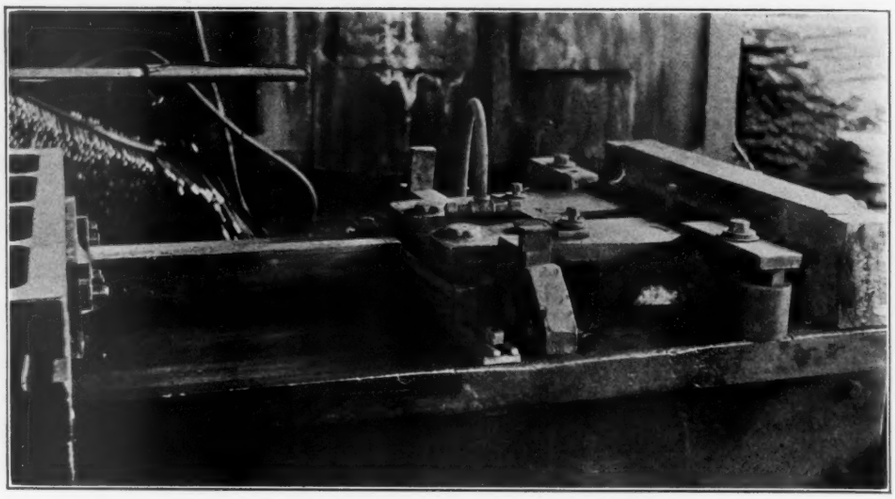


FIG. 32.—BRAKE SHOE KEY FORGING DEVICE ON BULLDOZER.

COSTS OF OPERATION FROM JANUARY 1 TO AUGUST 31, 1905.

Cost of materials	$172,916.40
Wages paid to direct labor	49,174.98
General expenses	90,698.54
Total	$312,789.92

Output 500 engines, costing each—		Per Cent.
For material	$345.83	55.3
For direct labor	98.23	15.7
For general expenses	181.50	29
Total	$625.56	100

Day wages are less than one-sixth of the entire expense; general expenses more than twice as much as labor; and material more than one-half the total expense. In the general expenses only the cost to the factory door is included.

A careful study of the cost of materials, and this is the largest item in the above statement, will undoubtedly show that a considerable saving may be made by such methods as described in the previous section of this article and by securing the co-operation of the men. The general expenses include the wages of all employes not directly chargeable to the different engines and the cost and maintenance of the belts, machine tools, the furnishing of power, etc.

In attempting to decrease factory costs the method is usually to make a reduction in the wages paid to direct labor, although as seen from the above figures this is the smallest item of the three. Suppose the wages are reduced 10 per cent., the best men will leave and those who stay are discontented, while the new employes are slow and unskilled. Less work will be done and more material wasted, and it is safe to assume that for the same number of men and the same amount of material 10 per cent. less engines will be turned out. There will, of course, be no opportunity to reduce the general expenses, and as a matter of fact more foremen will be required to teach the new men. The account will therefore stand:

Materials	$172,916.40
Ten per cent. less wages paid to direct labor	44,257.48
General expenses	90,698.54
Total	$307,872.42
An apparent saving of	4,917.50
Total	$312,789.92

But if we consider output, another story is told:

Output 450 engines, costing each—		Per Cent.
For materials	$384.26	56.2
For direct labor	98.34	14.4
For general expenses	201.55	29.4
Total	$684.15	100

Put the two results side by side:

Cost Before Wages Were Reduced.	Per Cent. of Direct Labor.	Cost After Wages Were Reduced,	Per Cent of Direct Labor.
$625.57	15.7	$684.15	14.4

Both the employer and employes are losers.

If, on the other hand, the matter of materials is first considered, it will be found that by following such methods as described in the preceding section of this article it will be

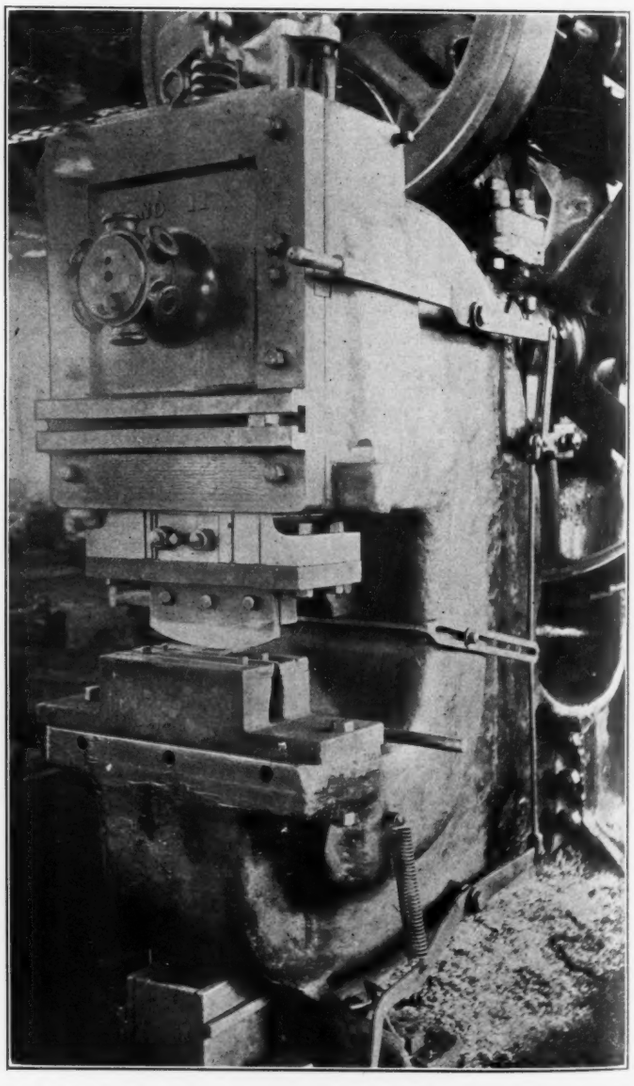


FIG. 33.—ATTACHMENT ON SHEAR FOR CUTTING BRAKESHOE KEYS TO SHAPE.

possible to make a very considerable saving in this item, and as the amount is so much greater than that paid for direct labor a small percentage would be equal to quite a large percentage of the direct labor charge.

Within certain limits the greater proportion of the general expense will remain about the same regardless of the output, and it is therefore, of course, advisable to increase the output to a maximum, making the charges against each engine due to this item a minimum. By improving the efficiency of the tools and machinery the output can readily be increased without increasing the expense as indicated by the results accomplished at Topeka. Assuming that the workman will co-operate to cut out unnecessary losses and wastes, if he is given an incentive, that the amount of increase of his pay depends upon his individual efforts, and that the average increase of pay amounts to 20 per cent., that the output is increased 20 per cent., but that the cost of material is increased only 10 per cent., and general expenses remain the same, the account would be as follows:

Materials	$190,208.04
Direct labor	49,174.98
Average increase, 20 per cent.	9,835.00
General expenses	90,698.54
Total	$339,916.56

Output of 600 engines, costing each—		Per Cent.
For material	$317.01	56
For direct labor	98.35	17.4
For general expenses	151.16	26.6
Total	$566.52	100

The employer pays his men an average of 20 per cent. more, and by all sorts of shop betterments, which cost a great deal to install and maintain, he enables them to obtain an average of 20 per cent. more output from the machines in the same time and without any more exertion to themselves; yet owing solely to the cutting out of useless wastes, the output costs 9 per cent. less. This 9 per cent. is the employers' gain. The method is one that benefits both wage-payer and wage-earner. Each, independently, has worked to reduce losses and wastes of materials, of supplies, of operation, of time, and they both share in the gain.

With the individual effort method the individual worker is rewarded in addition to his regular day wage. For instance, a time study is made of a particular piece of work upon which he is employed, and a schedule is made out and a reasonable standard time set such as any skilled man ought regularly to make. If the work is done in standard time the worker receives a 20 per cent. increase of pay above the hourly rate. He is paid this extra 20 per cent. not to work beyond reason, but to use his brains as well as his hands; to be his own foreman; to help keep conditions as they should be, and to assist the employer in maintaining high efficiency in tools and machinery. An illustration of the method used is indicated by the following diagram (Fig. 34) and table:

Hours to do Job.	Wages.	Bonus.	Wgs & Bonus.	Hrly rate of Man.	Mach. Cost.	Total Cost of Job.	Total Hourly Rate.
10	$2.40	.0	$2.40	0.24	$7.00	$9.40	0.94
9	2.16	.0	2.16	0.24	6.30	8.46	0.94
8	1.92	.0	1.92	0.24	5.60	7.52	0.94
7	1.68	.0	1.68	0.24	4.90	6.58	0.94
6	1.44	.0	1.44	0.24	4.20	5.64	0.94
5.8	1.39	.002	1.392	0.24	4.06	5.452	0.94
5.5	1.32	.010	1.330	0.242	3.85	5.180	0.942
5.2	1.25	.025	1.275	0.245	3.64	4.915	0.945
5	1.20	.039	1.239	0.248	3.50	4.739	0.948
4.9	1.18	.049	1 229	0.251	3.43	4.659	0.951
4.6	1.10	.084	1.184	0.257	3.22	4.404	0.957
4.3	1.03	.130	1.160	0.269	3.01	4.170	0.970
4	.96	.192	1.152	0.288	2.80	3.952	0.988
3	.72	.432	1.152	0.384	2.10	3.252	1.084
2	.48	.672	1.152	0.576	1.40	2.552	1.276
1	.24	.912	1.152	1.152	0.70	1.852	1.852
0	.0	1.152	1.152	Infinity	.0	1.152	Infinity

If the work is done in four hours, which is the standard time, the worker receives a 20 per cent. bonus. If more than four hours is used, and the work is finished in any time less than time and a half, or six hours, the worker still receives a bonus, depending upon the time which is taken. If more than six hours is used, the worker receives no bonus, but, of course, receives his day rate. If the work is done in less than standard time, the worker is given all the gain due to his own time. The employer gains the saving in the machine rate and surcharge, and the total cost of the job to him steadily decreases as the time required is reduced as indicated in the table. As it costs about $1 per hour to operate a man and machine, whether he works fast or not, the enormous economy of fast operation is apparent.

The following example taken from Mr. Emerson's paper shows clearly why it is to the employer's interest not to reduce the standard time so that it will be impossible for the worker to earn the 20 per cent. bonus:

"The worker wants to know, however, what is to prevent the employer from arbitrarily reducing standard time so that it will be impossible to earn 20 per cent. extra. The answer is that self-interest stands in the way, the self-interest of the employer, and this is the strongest protection of the worker. Nothing compels the employe to try to make standard time. If he does not think that he is treated fairly, he will not put forth the same effort, and the employer loses far more than he does. The schedules are intended to be as fair as they can be made. If found not to be fair, they should be revised and adjusted in the interests of both parties. For example: Standard time of turning locomotive drivers, four hours; man's rate, $0.30; extra pay per hour, $0.06; general expenses per hour, $0.60."

The cost at four hours:	
Wages	$1.20
Individual effort reward	.24
General expenses	2.40
Total	$3.84

"The employer reduces standard time to three hours, and the employe drops back to five hours. He can just as well do this, for he would make nothing extra at his former time of four hours."

Total cost at five hours:	
Wages at $0.30	$1.50
Individual effort reward	.00
General expenses	3.00
Total cost	$4.50

"Because standard time has been cut the employer loses $0.86 and the wage-earner loses $0.30. The proverb says any one can lead a horse to the trough, but it takes a wise man to make him drink. The employer can do his share, but his trouble and expense will be in vain unless he can induce the wage-earner to co-operate; and the cheapest, easiest method to secure and maintain co-operation is to offer an attractive increase of pay. Under no other system can the employe so effectively protect himself."

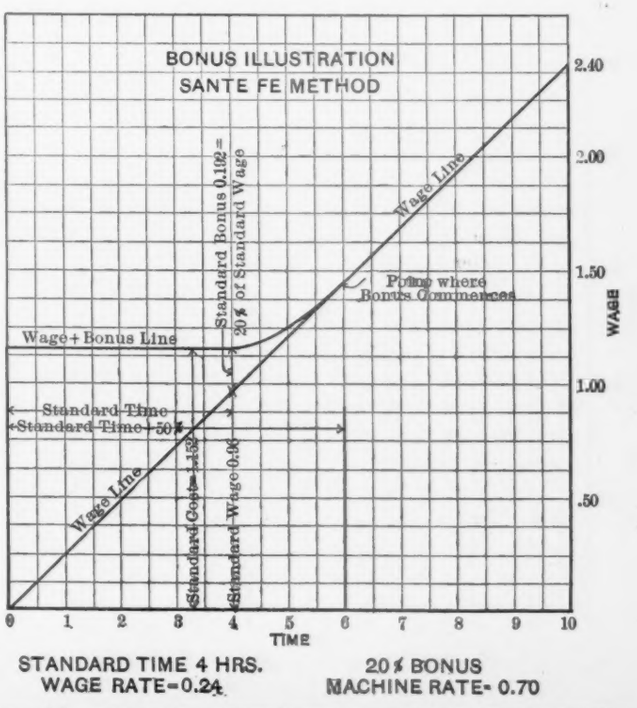


FIG. 34.—GRAPHICAL ILLUSTRATION OF INDIVIDUAL EFFORT METHOD.

The advantages of the individual effort method are also clearly summed up by Mr. Emerson as follows:

1. The standard time set is reasonable, and one that can be reached without extraordinary effort; is, in fact, such time as a good foreman would demand.

2. An extra reward of one-fifth of the regular wages for the operation is given to whoever makes standard time.

3. Extra compensation above the hourly rate is paid even if standard time is not reached, although this extra compensation diminishes in percentage above standard time.

4. If longer than time and a half is taken, the regular day rate is paid. Of this the wage-earner is sure.

5. Standard time is carefully determined by observation and experiment, and is only changed when conditions change.

6. The arrangement is one of mutual benefit to both parties—of increased earning to the worker, of increased saving to the employer.

7. The employer loses more than the wage-earner if schedules do not encourage co-operation.

8. The wage-earner, working on a schedule, becomes in a large degree his own foreman.

9. The wage-earner determines his own earning power, and by co-operating to cut out wastes increases his own value.

The direct results of shop betterment and individual effort are:

FOR THE EMPLOYE.

To shorten the hours of labor;
To enable each man to determine his own earning capacity;
To increase earnings;
To do away with overtime;
To make him self-reliant;
To add to his value as he grows older;
To add to his comfort and safety in the shop;
To harmonize relations with the employer.

FOR THE EMPLOYER.

To decrease the cost of production;
To lessen the delays on each job;
To lessen careless wastes and breakages;
To increase the output for the same investment of capital;
To secure a higher class of employes;
To harmonize relations with employes.

Application of the Individual Effort Method at the Topeka Shops.

The individual effort method was introduced gradually at the Topeka shops, the tools, machinery and shop methods first being improved to a high point of efficiency. At the present time the bonus system has been extended to all of the work in the erecting shop and to about 80 per cent. in the east machine shop, 50 per cent. in the west machine shop, 70 per cent. in the brass department, 75 per cent. in the smith shop, 5 per cent. in the tool room, 50 per cent. in the air pump and tinsmith's department; in the boiler shop only a small proportion of the work is bonused, largely because the gangs are small and the nature of the work is such that there is a continual shifting of the different members of a gang, making it almost impossible to place them on the bonus system.

The first step in drawing up a schedule is to make a careful time study under the general direction of a competent and trained man. An example of a time study is as follows:

15,66,08
Richard Roe, No. 0425.

Laying out and slotting brass and collar fit in new cast iron driving boxes, all boxes over 9 ins. brass fit; 20 per cent. steel cast iron:

	Actual Time		Estimated Time	
	Mins.	Secs.	Mins.	Secs.
Putting box on machine	—	35	—	35
Clamping down, setting box	8	02	5	—
Cutting	14	52	14	52
Turning tool around	—	42	—	42
Cutting	11	39	11	39
Changing tool, grinding	2	19	1	—
Cutting	2	56	2	56
Changing tool	1	56	—	42
Broken spring, time lost	46	20	—	—
Cutting	53	23	40	—
Changing tool and belts	1	15	1	—
Cutting	3	39	3	39
Changing tool	1	35	—	50
Cutting	5	3	3	39
Taking off box	3	32	2	—
Total	.2 37	57	1 28	34

Standard time adopted, 1.5 hours.

The number of the machine is 15,66,08. Fifteen indicates the class of machine, 66 its location (east side of the machine shop, south end), 08 indicates that this is the 8th operation or schedule on this particular machine. The man's number is 0425, 04 indicating the shop in which he works. In making a time study the operator follows his usual methods. The expert, who is a practical machinist, is equipped with a stop watch, and carefully observes every operation, and makes a note as to the speeds, feeds, depth of cut, condition of machine, belts and tools, and from these observations a standard schedule is made up. In some instances it is, of course, advisable to have the specialist perform the work himself. Up to the present time about 4,000 time studies have been made at the Topeka shops.

It will be seen from the above time study that there is no change made in the time that the machine is actually cutting, but that all wastes are cut out. The time study is carefully checked by several different persons, and is usually compared with standard records of similar work or performances in other shops. When a time study is made and a standard time is decided upon, a bonus schedule is drawn up about as follows:

No. 156,608.

INDIVIDUAL EFFORT SCHEDULE.

For laying off and slotting for brass and cellar fit cast iron, 20% steel driving boxes; all boxes over 9" brass fit.

Machine slotter No. 1566. Hourly rate, $0.50.
Tools, blue chip steel. Workman's rate, $0.25 per hour.

Time.	*Wages.*	*Bonus.*	*Total to Man.*	*Rate Per Hour.*
2.25	.5625	.0	.5625	.25
2.2	.55	.002	.552	.251
2.1	.525	.006	.531	.253
2.	.50	.012	.512	.256
1.9	.475	.02	.495	.261
1.8	.45	.03	.48	.267
1.7	.425	.042	.467	.275
1.6	.40	.057	.457	.286
1.5	.375	.075	.45	.30

Remarks: ----------

Checked by ----------
Supt. of Shop.

Shop Expert.

Approved by ----------
March 1st, 1905. Supt. Motive Power.

On the contract given the operator, only the first and third columns appear, as it is these that he is most interested in.

Before the schedule can be placed in operation it must be checked by the shop superintendent and the shop expert, and must be approved by the superintendent of motive power.

"The schedule is a moral contract or agreement with the man as to a particular machine operation, rate of wages and time. Any change in man, in his wage rate, in the machine, or in the operation, calls for a new schedule. If a schedule proves too low, it is raised; if it proves too high, the insignificant loss is temporarily suffered by the company. The moral contract with the man should never be violated."

The foremen, as well as the men, are bonused. Following is the schedule for the machine shop foremen:

SCHEDULE FOR GENERAL MACHINE SHOP FOREMAN AND FOREMEN OF EAST AND WEST SIDES OF MACHINE SHOP.

Bonus to be paid, based on the number of engines turned out per month and engine equivalent of manufactured material shipped.

A standard time to be assigned for all work done on each manufactured article finished in these departments; this time to be taken from individual effort schedules, where possible, and estimated in other cases.

The total average number of hours per engine for all labor in these departments to be determined by the preceding month's records of engines repaired.

Total number of hours devoted to manufactured material shipped, divided by average hours per engine, will give engine equivalent of manufactured material.

Manufactured material reduced to engine equivalents added to shop output of engines determines number of engines on which bonus will be paid.

For each engine, and fraction thereof, completed during the month, a bonus of $1.40 will be paid, divided among the foremen

E.J.A.Co. 5 05 100M. (Form 1264 Std.)

Santa Fe

Santa·Fe

Machine SHOP DAY WORK CARD.

No. 425 Name W. J. Amann Rate $0.25

No. 1566 Machine Slotter Rate 0.50

No Pcs	DESCRIPTION OF PIECE AND OPERATION	CHARGE	ON Date	ON Time	OFF Date	OFF Time	HOURS Job	HOURS Day	WAGES	BONUS No.	BONUS Earned	TOTAL
3	L 1241 Dis. Boxes slotted 9½" 20% steel	50 129 32	3/11	11.6	3/11	16.6	4.0		1 00	08	35	1 35

Rate checked by | Time checked by | Bonus checked by H.H.R. | Work authorized by

Foreman.

FIG. 35.—TIME DISTRIBUTION CARD (ON MORE RECENT CARDS PROVIS ION IS MADE FOR CHECKING IN AND OUT BY TIME CLOCK ON ONE END OF CARD).

as follows: General machine shop foreman, 45 per cent.; east and west side machine foremen, 27½ per cent.

For each day any machine work is delayed beyond date set for same on erecting floor schedule, a deduction of three cents per engine will be made from the bonus earned by machine foreman causing the delay and that of general machine shop foreman.

For each day engine machine work is completed in advance of schedule date, an additional bonus of three cents per engine will be added to bonus earned by general machine shop foreman and machine foreman to whom advance is credited.

Bonus account will be settled monthly.

In the erecting shop the same principle is used, although its application is modified to suit conditions, and possbly it can best be described by reproducing a schedule used by one of the erecting floor gangs:

LINK GANG.

No. 0000-18.

For repairing and putting on engines as they pass through the shops for repairs: Links, blades, motion bars, tumbling shaft, rocker shaft, boxes, reverse lever, reach rods, quadrant, all stands, hangers, brackets, bolts, bushings, bearings or boxes, balance springs, machine work and connections for above, and all necessary work to put them in first-class condition.

Standard clauses as herewith apply:

Standard wage cost of gang per 50 hours, $180.
Standard wage cost per hour, $3.60.

Gang output Per week of 50 hours.	When gang cost is $180.00 bonus will be	When gang cost is $170.00 bonus will be
5 engines	$0.00	$2.50
6 engines	10.80	14.40
7 engines	21.60	28.80
8 engines	32.40	43.20
9 engines	43.20	57.60
10 engines	54.00	72.00
11 engines	64.80	86.40

STANDARD CLAUSES FOR GANG 18.

GANG AND FOREMAN.

The company will pay a bonus as provided herewith to the foreman and men composing this gang, provided the minimum of five engines is turned out each and every week during the month:

Engines will be counted when the work is completed satisfactorily to the foreman.

Engines will not be counted: (1) when the work is improperly done; (2) if overtime has been worked; (3) if needed to make up any deficiency below five engines in final total for each preceding week of the month.

On the minimum output of five engines per week, 25 per cent. of any reduction in wage cost of gang below allotted wage cost will be allowed to the gang as a bonus. For any output in excess of the minimum, bonus as provided by the table herewith will be paid, and for each dollar reduction in labor cost of gang below allotted cost 3 1-3 per cent. of the bonus fixed by the output for the week will be added to that bonus and the whole divided as provided by schedule.

If the wage cost exceeds the allotted cost, no bonus will be paid. A fresh start, with no arrears to make up, will be made the first week of every month.

Bonus as thus provided for in schedule will be divided among foreman and men working in gang in proportion to their wages and time worked.

FOREMAN.

In addition to such bonus as the foreman may earn, as provided above, for each engine turned out satisfactorily on or before the date as set for same on erecting floor schedule, a bonus will be paid, as follows:

(1) For completing all bench work of the link gang, $0.25 for each engine.

(2) For hanging motion work on an engine complete, ready for valves to be set, $0.15 for each engine.

(Form 2022 Standard.)

Santa Fe.

INDIVIDUAL EFFORT CHECK.

Date 3/11/05 Sch. No. 5879

W. J. Amann No. 425

Mach. No. 1566 is entitled to $ 0.35

Remarks

Checked by: B. F. Payne

FIG. 36.—INDIVIDUAL EFFORT CHECK.

(3) For putting up rocker boxes, rocker shafts, tumbling shaft, and tumbling shaft boxes, reach rod, quadrant and reverse lever on an engine, $0.10 for each engine.

(4) For each day the above work is completed in advance of or delayed beyond the date set for same on schedule an addition to or deduction from the total bonus earned by foreman for the month will be made as follows:

Clause No. 1, $0.08 for each day.
Clause No. 2, .05 for each day.
Clause No. 3, .04 for each day.

(5) Engines passing through shop on schedule time, on which no link gang work is to be done, will be figured as completed on time, and clauses Nos. 1, 2 and 3 will apply.

(6) When roundhouse work, after trial trip, requires more than one day to complete, such delays will be counted against foreman

and a deduction of 17 cents for each day will be made from the total bonus earned by the foreman for the month.

(7) When work cannot be completed within allotted time on account of being delayed by other gangs, or by storehouse, such interval of delay will not be considered in figuring bonus.

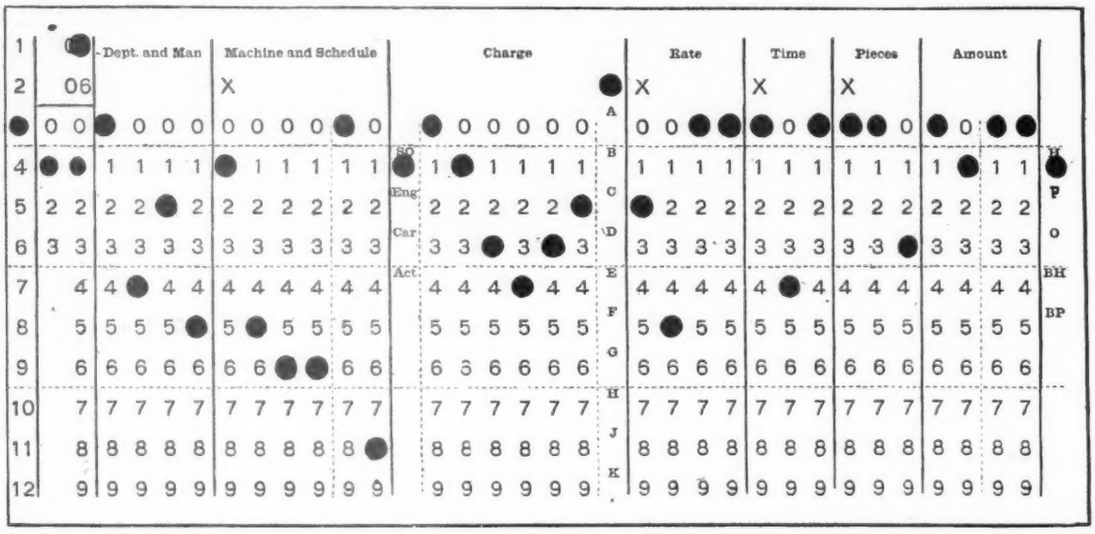


FIG. 37.—LABOR CARD USED WITH HOLLERITH TABULATING MACHINE. (BLACK SPOTS INDICATE HOLES PUNCHED.)

Each workman has a time distribution card, as shown in Fig. 35, provision being made for checking in and out on the end of the card. The timekeepers enter upon these cards the necessary information as to the work done by each workman, and from this the bonus is calculated. At the present time seven timekeepers are required, one in the erecting shop (about 200 men), three in the machine shop, or one to about 60 men, two in the boiler shop, and one in the blacksmith shop (about 160 men). As will be seen later, the timekeepers in the machine shop assist quite materially in making it possible to control the shop from a central station. Every morning the worker is given what is known as an individual effort check, Fig. 36, showing the amount of his bonus for the previous day, and is thus encouraged in his work.

Tabulating Records.

Hollerith tabulating machines, developed by Dr. H. Hollerith, and used for tabulating census records, are used by the accounting department in calculating the wages and bonus for each man or in finding the amount to be charged to different engines or shop orders or any other information of this kind.

In tabulating records by means of these machines three operations are necessary. In the first place cards similar to those shown in Figs. 37 and 38 must be punched. The first of these cards is known as a labor card and the second as a bonus card. By comparing these two cards with the time distribution card shown in Fig. 35 the scheme of punching them may readily be seen. There is a hole in every column except where the top X is punched, in which case the whole field is skipped. The date 3—11—05 is punched by a gang punch, a large number of cards being punched at the same time. The man's number is 0425, and indicates his hourly rate as well as his number. The schedule number 15,66,08 indicates the kind of machine, the machine location and schedule. The work is charged to Shop Order No. 13432. The man's rate is 25 cents, the time taken is four hours, the number of pieces three and wages paid $2.

The bonus card is similar, except that it shows the bonus earned, 35 cents. A distribution card will show an average of three operations per day, requiring six of these cards. The operation of punching is a simple one, and requires less time than if the records were to be entered in a book or on a sheet. One man can punch from 1,500 to 3,000 cards per day.

The second operation is to sort the cards into groups. Suppose, for instance, that it was desired to tabulate the cards according to different shop orders. The cards would be fed into the machine and sorted at the rate of about 200 per minute. They could then be run through a tabulating machine at the rate of 40 or 50 cards a minute, and the time or cost on a particular order could quickly be obtained. By means of these machines it is possible to determine quickly and accurately information concerning almost any operation or phase of the work.

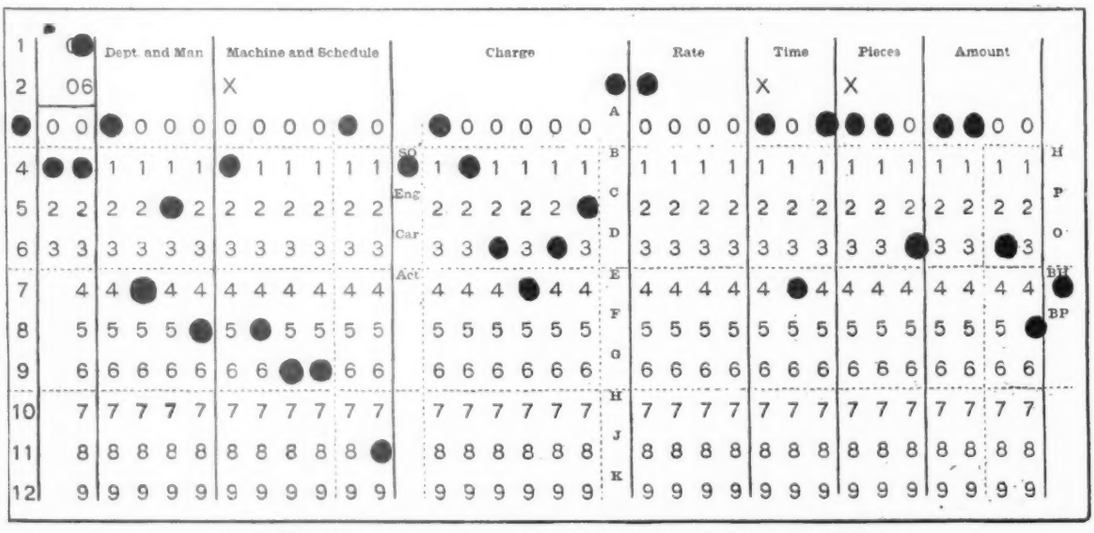


FIG. 38.—BONUS CARD USED WITH HOLLERITH TABULATING MACHINE.

If desired, a third card may also be made out, preferably of a different color, to show the machine charge for each piece of work. An idea of the wide range of work which may readily be done on these machines with the three sets of cards described above may be gained from the following extract from one of Mr. Emerson's reports:

What do these cards give us? Almost every possible fact wanted. They are sorted by a machine and tabulated also by a machine. Assume 200,000 cards recording a month's work. The following questions are propounded for answer:

(1) What was total number of hours worked by all operators? Run all the work cards through tabulating machine set for hours.

(2) What is payroll for each group? Sorting machine is set for the different groups and cards run through, thus being sorted into piles corresponding to groups or shop subdivisions. Each pile is run separately through the tabulating machine, which thus gives payroll for each group. These are then reduced to hour basis and entered on comparative sheet of previous month and year.

(3) What is total payroll for month? Add the totals of groups together.

(4) What is due each man? Take group piles and sort according to men, then tabulate.

(5) What were total machine earnings in each group? Take machine cards, sort by groups, and tabulate.

(6) What were total machine earnings? Add earnings of each group.

(7) How shall machine earnings be distributed? From group earnings to various accounts: so much for power, depreciation, etc.

(8) How many hours did all the machines work? Tabulate all machine cards on hours. This will enable good estimate to be made as to needs of new machines.

(9) How many hours did each machine work? Sort according to machines.

(10) How many different jobs did certain men do? Sort either on machine or by shuffling the pile of the individual man.

(11) How many men worked on same machine job? Sort machine cards or men's cards as to jobs and make comparisons. As cost of same work varies 100 per cent. with different men on it, this is an important possibility.

(12) How many different kinds of jobs did certain machines do? Shuffle the cards of the machine according to the jobs.

(13) On how many different machines was the same job done? Sort as to job; but more quickly determined by picking out specific cases as to two or more known machines. The object is to know whether a job is done more cheaply on one machine than on another.

(14) What was the total of all the charges against a given repair job, say, locomotive 256? Run through sorting machine (set for 256) all the cards that are likely to include this job, and tabulate.

(15) What were the direct charges? Tabulate the sorted labor cards.

(16) What were the bonus charges? Tabulate the sorted bonus cards.

(17) What were the machine charges? Tabulate the sorted machine cards. These sortings and tabulations can be used to determine the exact cost of each operation.

(18) How many hours did the men work on the 256 locomotive repair job? Tabulate the men's cards by hours.

(19) How many hours did the machines work? Tabulate the machine cards by hours.

(20) What men worked? List them from the sorted cards.

(21) What machines worked? List them from the sorted machine cards.

(22) Without having kept any records other than the punched cards, in a few hours one can ascertain the cost during the month to date on any particular piece of work.

When the work which is handled by these machines is considered, it is remarkable that so small a force is required. The visit to Topeka was during the early part of the month, and a large amount of work was required in order to finish up the monthly records. There were only three young men employed in this department. There were two sets of punches, so that two of them could punch cards at the same time, if desired. There were two sorting machines and two tabulating machines, and the rate it was possible to punch, sort the cards and tabulate any number of them to obtain various data was remarkable and almost inconceivable. The force which would be required to do the same amount of work by ordinary means would be many times greater. The machines, of course, furnish absolutely accurate results, providing the cards are properly punched.

Cost Accounting and the Surcharge Problem.

The following account of the cost accounting is taken from a description of the betterment methods in operation at the Topeka shops in a report made by Mr. Emerson to Mr. J. W. Kendrick, second vice-president.

It should, however, be kept clearly in mind that cost accounting is a part of shop practice and not necessarily of auditing interest. From the shop point of view, in order to compare its own costs at different periods, or with costs at other shops with the prices at which material can be purchased, all the elements of rent, machine charge, power and supervision should be determined for each operation.

* * * * * * * * *

The usual methods of determining costs are not as good as sensible guesses, and require most cumbersome systems, which have justly brought the whole idea of accurate cost determination into disrepute. An adequate cost system must fulfill several requirements. It must be exceedingly simple, yet reliable. It must give promptly all the information required. It must make greater efficiency or excellence easy and pleasant, laxity and inefficiency very disagreeable. But reliably accurate, very suggestive and immediately available cost determinations can be secured almost incidentally and without effort.

All that is necessary is to determine (1) the machine-hour rate and (2) that part of general expense to be assessed as a per cent. of wages against each sub-group of men, and the problem is solved for all time. To do this initial work well requires considerable experience and judgment, but when it has once been done the system is simplicity itself. The method of doing this will, as to shops similar to those of the Santa Fe at Topeka, be fully described.

In a large shop spending $240,000 a month:

Materials used amount to		$120,000
Direct labor		74,470
Supervising and assisting labor	$21,855	
Materials for supplies, operation and maintenance	12,349	
Book account charges (mainly interest and depreciation)	11,326	45,530
		$240,000

Certainly enough is paid for administration and operating charges to call for the highest efficiency. Usually, records and accounting are full and complete as to totals, but they exist in most fragmentary and unreliable shape as to details. Materials are indeed drawn on requisition and men are checked in and out, but what actually becomes of the material issued or of the day checked, is at best only approximately known, and approximations are of small value for shop betterment endeavors. The Mississippi flows approximately south, but this fact is of small use to the pilot who wants to know the exact location of every bar and snag.

Man and Machine Surcharges.—In every shop there are general expenses, and there is little question as to their aggregate amount. It has thus far proved almost impossible to distribute them properly to each separate operation. The fear of the detail work that might be necessary has hitherto deterred both accountants and shop managers from attempting cost determinations as a regular part of daily duties, but the time-distribution record of shop operation, as well as the Hollerith methods of sorting and tabulating, make an accurate determination easy and quick.

All general expenses can be apportioned for convenience to the four heads:

Rent	$8,000
Supervision	14,530
Maintenance and operation of equipment	18,200
Power (light, heat, water, etc.)	4,800
	$45,530

These items are in detail, subject to revision and change. No two specialists would ever wholly agree as to exact apportionment of power, or rent, or maintenance, or supervision.

The same subdivisions are followed with each separate shop and subdivision of shops. The two main subdivisions at Topeka are the locomotive and car departments.

	LOCOMOTIVE SHOP.		CAR SHOP.		TOTAL.
	Men.	Machines.	Men and Machines.	Sundries.	
Rent	$2,925	$2,075	$3,000	.....	$8,000
Supervision	8,595	85	5,850	.....	14,530
Maintenance	3,229	8,271	6,700	.....	18,200
Power	789	2,846	793	$372	4,800
	$15,538	$13,277	$16,343	$372	$45,530

The distribution of these four items of general expense is shown in the three following tables, apportioned not only to the main departments and their subdivisions, but also in the locomotive shop to man and machines.

No very grave error would have been committed, had the general expense been assigned one-third each to men in the locomotive shop, machines in the locomotive shop, and to the car shop. As to the locomotive shop, the general expense might have been apportioned equally to the men and to the machines. In making the distribution, rent has been apportioned to each equally, except for those buildings or parts of buildings occupied exclusively by men. Power, and also small tools used on the machines, have been charged to machines.

Light and heat, as well as air tools, have been charged to the men. Supervision has been to, perhaps, an undue degree charged to men, but this item includes all the general labor not easily distributable to special jobs.

The division above made is a first approximation only, to be corrected as additional facts are gathered. It is a matter of, at most, a day's work for one accountant to distribute to machines and men groups any changed apportionment that may be decided on. So simple is the work that I should not hesitate to advise revising the surcharges and machine rates monthly, or at least quarterly, until uncertainty has been eliminated, basing each monthly rate on the average of the preceding twelve months, thus again, by gradual approximations, reaching ideal accuracy.

The percentage column ending each table is the valuable part of the whole work. As to men in each group, it shows just what percentage must be added to their wages to cover the general expenses as to men.

As to machines in each group, it shows just what percentage

DISTRIBUTION OF MONTHLY GENERAL EXPENSE IN CAR DEPARTMENT.

	(1) Pay-Roll Direct Labor.	(2) Payroll Surcharge Labor.	(3) Rent.	(4) Supervision.	(5) Maintenance and Operation.	(6) Power.	(7) Total General Expenses, (3, 4, 5 and 6).	(8) General Expenses and Surcharge Labor to be Charged as per cent. to Direct Labor, (2 and 7).	(9) Total Expenses, (1, 2 and 7).	(10) Per Cent. of General Expense to Direct Labor.
Planing Mill	$3,100	$500	$500	$940	$2,095	$450	$3,985	$4,485	$7,585	145 %
Freight Cars	14,200	1,050	600	1,455	715	25	2,795	3,845	18,045	25 %
Coach Shop	6,100	500	500	590	210	7	1,307	1,807	7,907	30 %
Paint Shop	4,500	150	800	260	115	6	1,181	1,331	5,831	30 %
Wheel Shop	2,400	300	100	350	1,530	195	2,175	2,475	4,875	100 %
Upholstery Shop	400	25	50	110	45	5	210	235	635	60 %
Cabinet Shop	3,000	300	400	590	525	100	1,615	1,915	4,915	65 %
Plating Shop	250	25	50	105	65	5	225	250	500	100 %
Total	$33,950	$2,850	$3,000	$4,400	$5,300	$793	$13,493	$16,343	$50,293	50 %

DISTRIBUTION OF LABOR, MONTHLY GENERAL EXPENSES IN LOCOMOTIVE SHOP.

SHOPS.	(1) Payroll of Direct Labor.	(2) Payroll of Surcharge Labor.	(3) Rent.	(4) Supervision.	(5) Maintenance.	(6) Power.	(7) Tool Room as Surcharge.	(8) Total General Expenses, (3, 4, 5, 6, and 7.)	(9) General Expenses and Surcharge Labor to be Charged as Per Cent. to Direct Labor, (2 and 8.)	(10) Total Expenses, (1, 2 and 8.)	(11) Surcharge Per Cent. on Direct Labor.
Erecting Floor	$13,900	.....	$850	$1,095	$2,385	$259	$130	$4,719	$4,719	$18,619	35 %
East Side Machine	3,700	$1,110	180	1,985	45	70	.....	2,280	3,390	7,090	60 %
West Side Machine	1,800	480	180	1,135	30	25	.....	1,370	1,850	3,450	85 %
Brass Room	1,400	175	50	535	40	8	.....	633	808	2,208	45 %
Tool Room	1,000	100	40	430	20	8	.....	498	598	1,598	50 %
Air Room	750	.....	20	145	15	8	5	193	193	943	25 %
Boiler Room	9,550	185	905	1,325	100	100	35	2,465	2,650	12,200	25 %
Forge Room	6,800	500	600	1,400	365	300	.....	2,665	3,165	9,965	40 %
Pattern Shop	620	80	50	310	115	8	.....	483	563	1,183	80 %
Tin Shop	1,200	50	50	235	114	8	5	407	457	1,657	35 %
Total	$40,520	$2,680	$2,925	$8,595	$3,229	$789	$175	$15,713	$18,393	$58,913	45 %
General Expenses exclusive of Tool Room.								$15,538.			

DISTRIBUTION OF MONTHLY MACHINE GENERAL EXPENSE IN LOCOMOTIVE SHOP.

SHOPS.	(1) Value of Productive Machine.	(2) Value of Unproductive Machines.	(3) Rent.	(4) Accounting.	(5) Maintenance and operating.	(6) Power.	(7) Tool Room as Surcharge.	(8) Total General Expenses per month, (3, 4, 5, 6 and 7.)	(9) Total Surcharges per year.	(10) Percent of Surcharge to value of Productive Machines.
East Side Machine	$50,000	$4,000	$180	$30	$2,765	$280	$150	$3,405	$40,860	80 %
West Side Machine	57,000	11,000	180	10	1,530	144	25	1,889	22,668	40 %
Brass Room	16,000	2,000	50	10	715	32	80	887	10,644	70 %
Tool Room	8,200	2,000	40	5	310	20	.....	375	4,500	55 %
Air Room	1,500	1,000	20	5	155	22	5	207	2,484	170 %
Boiler Shop	43,000	18,000	905	15	1,545	1,390	10	3,865	46,380	110 %
Forge	45,000	9,000	600	10	1,050	934	.....	2,594	31,128	70 %
Pattern Shop	2,500	1,500	50	.....	170	20	.....	240	2,880	100 %
Tin Shop	1,000	2,300	50	.....	31	4	5	90	1,080	110 %
Total	$224,200	$50,800	$2,075	$85	$8,271	$2,846	$275	$13,552	$162,624	75 %
Total Surcharges exclusive of Tool Room.								$13,277.		

of the inventory value must be charged annually to cover the general expenses as to machines.

The hourly rate of a machine is ascertained by looking up its inventory value, multiplying this by the per cent. of surcharge determined for that group and dividing by the number of hours it is used in the year.

To illustrate: A man on the east side of the machine shop, whose wages are $0.30, works four hours on a machine whose inventory value is $5,000, and which is in use 2,000 hours in the year.

What is the cost of operation, exclusive of material?

Wages, 4 hours at $0.30	$1.20
General expenses as to man, 60 per cent. on wages	.72
Yearly machine rate, 80 per cent. of $5,000, or $4,000; working 2,000 hours, hourly rate $2	8.00
Total	$9.92

The operation cost of each and every job should include the

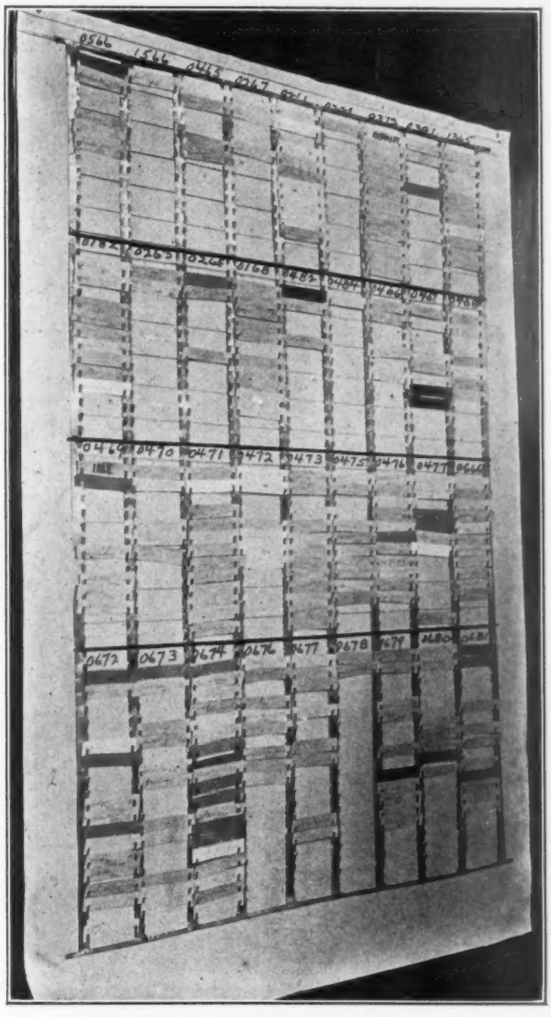


FIG. 39.—MACHINE SHOP DISPATCHING BOARD.

three items: labor, general expenses as to man, and general expenses as to machines. As a book account, these items should be credited each month, wages to direct payroll account, the two other items in percentages to the different accounts of rent, supervision, maintenance and operation, and power.

To what extent these various funds and apportionments to them shall be subdivided is an unimportant question of detail, to be decided according to circumstances. All rent earnings can be credited to the total rent charges, or the rent earnings of each department can be credited to the specific charges against that department.

There is very little question but that the greater accuracy, if its lessons were consistently followed up, would abundantly pay. It is not unimportant, on the contrary vitally important, to ascertain that in one department rent is the heaviest charge; in another, maintenance; in a third, power. In the boiler shop, for instance, power costs $1,390 a month, or 14 per cent. of the active payroll of $9,950. On the erecting floor, maintenance of equipment (air tools) is $2,385, or 17 per cent. of the active payroll of $13,900. In the boiler shop, $1,000 a month might have been saved, had it been known that certain machines were exceedingly expensive as to power, and on the erecting floor $1,000 a month can probably be saved by careful supervision over small tools and their repairs.

In shops, thousands of dollars melt away in cents and dimes. The object of modern shop accounting is not only to follow the equivalent of every cent into output, but also to be able to make comparisons and discover leaks. It is just as important to adopt a method that is $0.10 cheaper than another method as to avoid paying a man $0.10 too much.

[This question of surcharges in a railroad shop was quite thoroughly treated in an article by Mr. J. C. Morrison, material supervisor at the Topeka shops, on page 376 of our October issue. Several communications concerning this article appeared in our November issue, and replies to these will be found on another page of this issue, including a more complete description of the method of determining the surcharge.]

It is not essential that auditors should take any notice of these costs. It may satisfy them to charge merely direct labor and material, covering the other charges in some different manner. So entirely distinct are *shop costs* and *auditing charges* that the former should be standardized and entered up *before* a job is begun. The former are for the information of shop superintendent and other officials and determine shop, foreman and mechanic's efficiency.

Control of the Machine Shop from a Central Station.

Imagine, if you can, how the trains on a large railroad system would get along if it was attempted to operate them without a train dispatcher. If engines are to be repaired in a shop in a minimum amount of time, it is just as necessary to have the work drected from a central station, rather than by a "hit and miss" method. One of the most interesting features in connection with the Topeka shops is the fact that the general machine shop foreman directs the work of the shop from his office, and seldom finds occasion to leave it. Splendid results are being accomplished. The method of doing this was evolved and perfected by Mr. Clive Hastings, assistant to Mr. Emerson.

The foreman sits in a revolving chair; before him is a desk with two telephones, one connecting to the east and one to the west machine shop. Near the desk is another telephone, connecting with the office of the general foreman. On the opposite side of his chair from the desk are three dispatch boards, similar to the one shown in Fig. 39. These are about 4 ft. wide by 6 ft. high and are divided into a number of divisions, the arrangement of which is more clearly shown in Figs. 40 and 41. The number at the top of each division is that of the machine; for instance, 0475 would be a lathe in the east machine shop. The first two numbers indicate the type of machine and the last two its position in the shop. The general machine shop foreman is, of course, familiar with the exact location of each machine in the shop and the work for which it is best adapted.

When a foreman finds that a certain piece of machine work is necessary, he fills in a requisition and sends it to the office of the general machine shop foreman. This requisition shows the shop order on which the material is to be used. The general machine shop foreman immediately makes out a slip, about 4½ ins. long by ⅞ in. wide, showing the number of pieces and the name of the part wanted, the shop order number, and the machine upon which the work is to be done. This small slip is then placed on the dispatch board underneath the number of the machine. If new material is required for an engine in the shop, a blue slip is used. If the material is for a new switch engine, some of which are being built at the Topeka shops, it is placed on a yellow slip. Rush or emergency orders are placed on red slips; repair material for engines in the shop on white slips; a shop order for the system on green slips, and repairs to machinery on pink slips.

By looking at the dispatching boards the foreman, knowing what work is to be hurried or is of the greatest importance, can quickly decide the next job to be done on any one of the machines. The slip at the head of the column, immediately under the machine number, indicates the piece of work in the machine. Shortly before this work is finished, the machine operator advises one of the timekeepers, or the foreman, and they telephone to the machine shop foreman and ask for instructions as to the next piece of work. By means of a messenger (two boys are employed), the order for the next job is sent to the machine operator in sufficient time, so that he need lose no time waiting for instructions or for the proper material.

It will be seen that there are six spaces under each machine number, corresponding to the number of working days in a week. As soon as a job is finished, the small slip is removed from the board and the information on it is copied in the

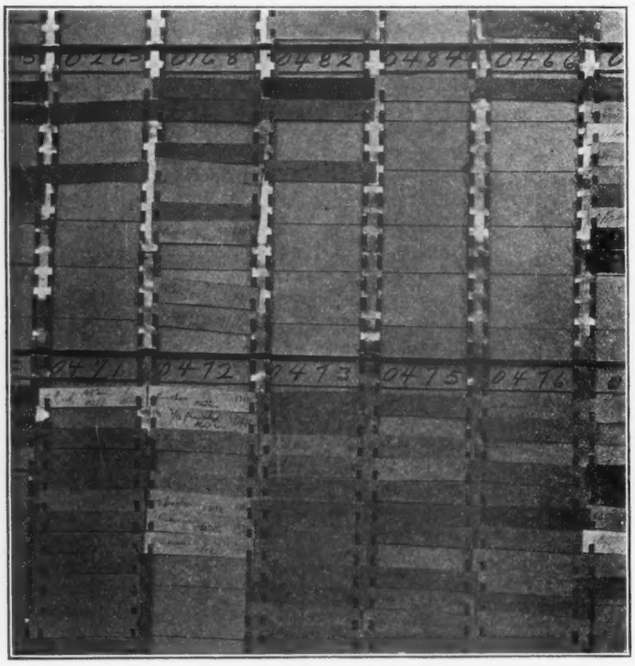


FIG. 40.—PARTIAL VIEW OF MACHINE SHOP DISPATCHING BOARD.

proper division in the column. At the end of the week it is, of course, necessary to put a new piece of paper on the board, the old piece being removed and kept on file. A complete record of all the work done on every machine in the shop is thus available, and may readily be referred to, if desired.

It is quite possible that the reader will smile as he reads this description. Several shop managers smiled quite broadly when they were told of it. It does sound like a Utopian scheme. Its effectiveness, however, is readily apparent by sitting down and watching operations in the office for half an hour or so. The general machine shop foreman is a busy man. Reports are continually coming in to him, either over the telephone or by messenger, and it keeps him pretty busy giving the necessary instructions as to the work to be done. It has been said that it is impossible for the foreman to accomplish results unless he goes out through the shop, but here we find a man who is perfectly familiar with every machine in the shop, has at hand the schedule showing exactly what work is to be done on each engine for each day it is in the shop, and he utilizes every moment of his time in planning and arranging the work. No time is lost in going from point to point in the shop.

Under the bonus system the men are anxious not to waste time, and in order to accomplish results they must have the work at their machines and ready to be put into place as soon as the previous piece of work is completed. This system of control forms an ideal method of accomplishing this result. It took some time to develop it and get it into its present form. At first, the method of using colored strings, such as used in a train dispatcher's office, was tried, but this method was found rather cumbersome and hardly fitted for a machine shop, and the present arrangement was devised.

The vertical strips are of tin with projections or clips behind which the slips can easily be dropped. The cross strips, to which these pieces of tin are soldered, are of heavy wire.

Material on store orders is not ordered from the storehouse until just before the machine is ready for it, in order not to litter the shop with surplus material. For machines that are laid up for repairs, or on which no operator is working, a slip is placed just underneath the number of the machine, marked "idle" or "repairs."

This plan may look theoretical and encumbered with red

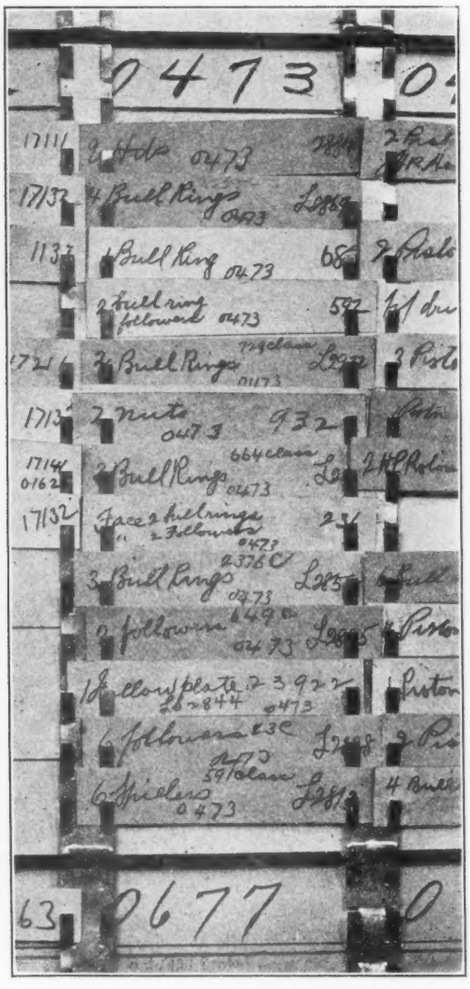


FIG. 41.—DETAIL OF DISPATCHING BOARD.

tape. One might expect to find the general machine foreman in this position, a visionary, over-educated theorist, instead we find in Mr. W. L. Jury, who now holds this position, a thoroughly practical mechanic, who was formerly an efficient foreman of the east machine shop.

Inspection of Engines and Work to be Done on Them.

When a master mechanic sends an engine to the shop he forwards a report to the shop superintendent as to its condition. When the engine reaches the hospital track, the inspector looks over the master mechanic's report, examines the engine, and makes out what is known as a "conditional" report, showing the condition of the more important parts of the locomotive, such as the firebox, flues, smoke arch, driving-wheel centers and tires, frames, crossheads and tender. This report, while, of course, only of a general nature, enables the shop superintendent, if there are several engines on the hospital track, to select the one which may be handled to the

best advantage in the shop at that particular time. For instance, if several engines are already in the shop requiring new fireboxes, it would not be desirable to place in the shop other engines requiring much work of this kind. In order that the shop may be brought to a high point of efficiency and economy, it is, of course, necessary to keep conditions as uniform as possible.

When the engine is placed in the shop for stripping, the inspector marks those parts which are to be stripped, at the same time dictating to a stenographer an exact statement of the work to be done by the stripping gang. By the time this report is written out, the stripping gang is usually just finishing its work, and the gang foreman goes over the statement and checks to make sure that the work has been properly done. As the engine is being stripped, the inspector carefully examines the various parts and prepares a detailed statement of just what work is to be done on the engine by each gang. A sample of one of these reports, and also a list of the different gangs in the shop, is given in Mr. Morrison's article on "The Locomotive Repair Schedule," on page 339 of our September issue. No work must be done on the engine or material used other than that called for in the inspector's statement, unless authorized by the shop superintendent.

The results accomplished by this system are two-fold. In the first place, only that work which is necessary on the engine is done and no time is wasted in taking down and replacing parts which are in good condition. In the second place, new material is not used unless it is necessary, and greater care is taken of the material which is stripped. Under former conditions a considerable amount of material was lost, misplaced, or stolen for use on other engines, and often new material was ordered when the old material could have been used to good advantage.

The inspector watches the progress of the work on the engine while in the shop. When it leaves the shop it is placed in charge of an engineer, whose duty it is to break in engines and give them a trial run. The engineer reports all defects, and the various gangs whose work has proved defective are given a certain amount of time to place it in good condition, after which time the engine is again carefully inspected by the shop inspector. If the work specified has not been done, a deduction is made from the bonus of the gang foreman, depending upon the amount of time which the engine is delayed. The other members of the gang, of course, lose, in that while they are doing this work in the roundhouse they are not keeping up with their regular work in the shop and will therefore lose proportionately upon their bonus for the next engine.

Estimating Locomotive Repair Costs.

As soon as the inspector has made his detailed report as to the work which is to be done upon an engine, a copy of it is given to the material supervisor and he at once proceeds to estimate the labor cost. When this feature was first started, the estimates were not very accurate, but after a number of engines of various classes had passed through the shop and detailed data was obtained as to the average time required for different operations, it was found possible to make fairly close estimates. Often it is found that additional work, not specified by the inspector, becomes necessary, and in such instances, after it has been authorized by the shop superintendent, the estimate is revised. A sample of one of these estimates, except that the third column has been added, which shows the actual labor cost of the work done on the engine, is shown in the next column.

The first estimate of $800 was increased to $873, due to additional work which was authorized, and it will be noticed that the actual cost was within $30.67, or 3.6 per cent., of the estimate. As soon as possible after an engine leaves the shop the actual cost for each gang is compared with the estimated cost. An estimate of this kind is useful in several ways; each gang knows that its work is being closely watched, and thus, in addition to earning their bonus, they have an incentive to keep down the cost. It also enables the shop superintendent and his assistants to keep in close touch with the work and detect any irregularities or weak spots and take measures to correct them.

Estimated and actual labor cost for engine No. 1000. Assigned to Aigner for heavy repairs.

Gang.	Estimated.	Authorized.	Actual.
*1.....	$54		$62.16
2.....	7		16.07
**3 or 4.	95	$150	151.06
5.....	27		25.30
6.....	3		
7.....	21		18.67
9.....	25		20.10
10.....	1		.68
11.....	5		5.96
12.....	20		18.76
14.....	23		14.60
15.....	4		8.64
16.....	11		11.53
17.....	16		13.91
18.....	35	39	41.99
19.....	15		14.60
20.....	22	30	33.00
21.....	26		27.45
22.....	23		19.32
23.....	5		9.47
24.....	12		17.35
25.....	0		
30.....	89		95.46
31.....	21		12.27
35.....	3		4.50
40.....	64		66.31
41.....	9		16.64
43.....			.18
47.....			1.89
50.....			.78
52.....	10		5.88
56.....			.51
70.....	21	15	12.63
Supv. Bonus, etc	133	145	156.00
Totals.....	$800	$873	$903.67

*Includes gang No. 13.
**Includes gangs 27 and 29.

Locomotive Repair Schedules.

An important feature in connection with the improvement of the output at the Topeka shops is the locomotive repair schedules. On page 338 of our September issue Mr. C. J. Morrison described these schedules and copies of the erecting floor schedules for light, heavy and general repairs were reproduced. In addition to these schedules, each gang has similar special schedules for their own work, and by means of the cardboard strips showing the working days in each month and the date upon which the engines entered the shop it is possible for them to determine immediately the time at which any part of their work is expected to be completed for a given engine.

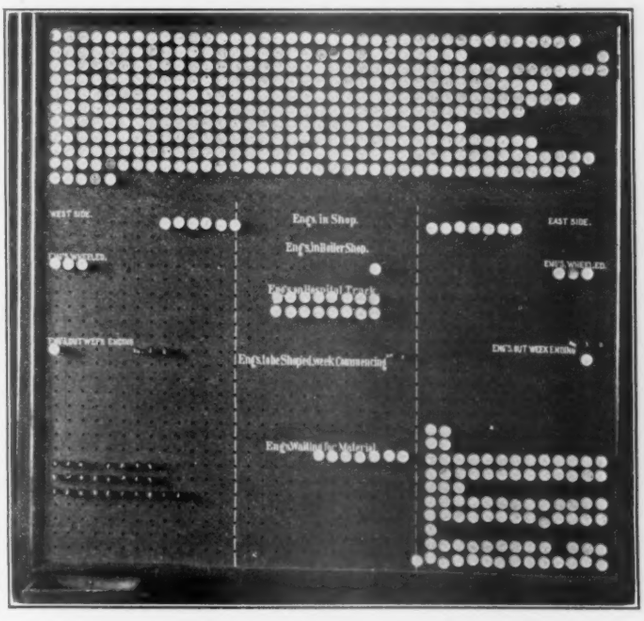


FIG. 42.—SHOP CONDITION BOARD IN SHOP SUPERINTENDENT'S OFFICE.

The subject was thoroughly treated by Mr. Morrison in the article cited above.

To keep the shop superintendent, the storekeeper and the betterment department informed as to the engines in the shop

and their condition, two kinds of diagrams or condition boards are used.

The photograph, Fig. 42, shows the board in the office of Mr. Purcell, the shop superintendent. Upon the round white discs, which are fitted with pegs, is shown the number of the engine, the date it was placed on the hospital track, the date it entered the shop, the name of the erecting foreman who has it in charge, and space is left for the date when the engine leaves the shop. The first row at the top shows the engines turned out during the month of January; the second during February; the third during March, etc. The engines are placed in these rows in the order in which they are turned out of the shop, beginning at the left. A white disc is also inserted for each Sunday or holiday as it occurs.

A somewhat different arrangement is kept in the offices of the counselling engineer and the general storekeeper. These may best be explained by the use of the diagram shown in Fig. 43. The figures at the top of the diagram show the number of days that the engines have been in the shop. The black spots on the diagram represent small blocks upon which the engine number is printed. The faces of these blocks are of different colors; for instance, a white block signifies that an engine has been wheeled; a yellow block that the engine is going through the shop on schedule and a red block that the engine is held for material.

The diagram shown in Fig. 43 shows the condition on March 30, 1906; and Fig. 44 shows the condition for the same date one year earlier. Comparison of these diagrams will

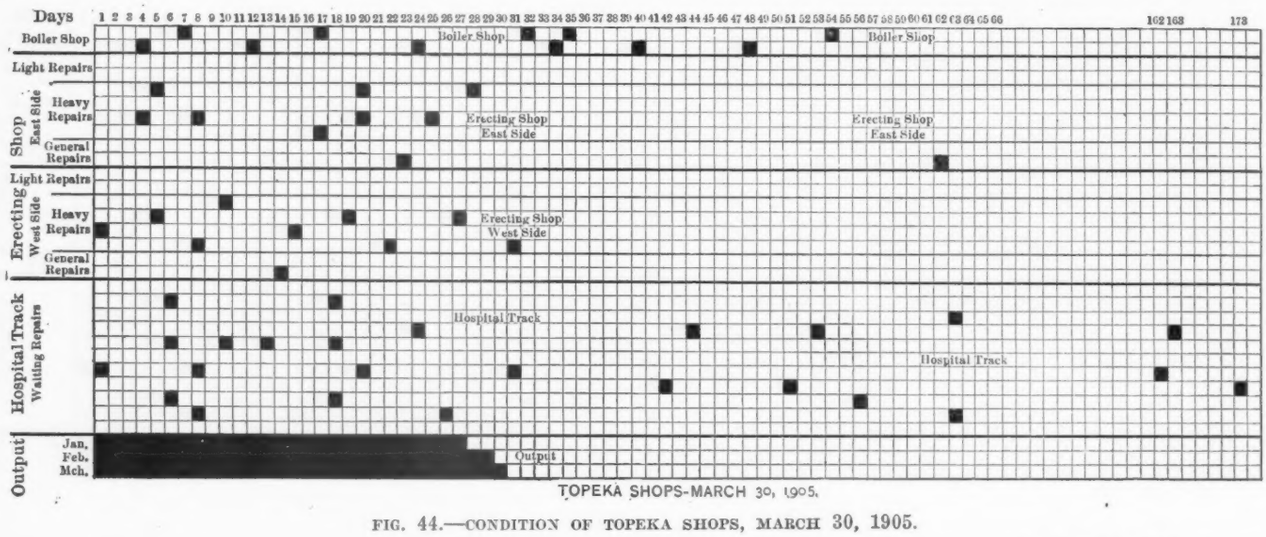


FIG. 44.—CONDITION OF TOPEKA SHOPS, MARCH 30, 1905.

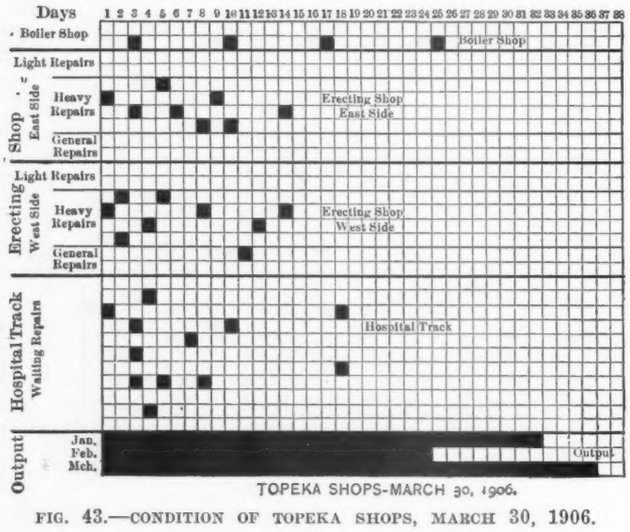


FIG. 43.—CONDITION OF TOPEKA SHOPS, MARCH 30, 1906.

show exactly what had been accomplished during the year in the way of shortening the time the engines were held in the shop and on the hospital tracks.

At the present time practically no light repairs are being made at Topeka, but the heavier repairs for the entire system are handled at that point. As stated in Mr. Morrison's article on "The Locomotive Repair Schedule," fourteen days are allowed for heavy and twenty-five for general repairs. The actual boards have sufficient space to show the output for one year.

At the end of the year a record is made of the upper part of this board and the pegs are removed.

Below this, on the left side of the board, is shown the engines on the west side of the shop. As soon as an engine is wheeled it is placed in the proper place on the board. When an engine leaves the shop it is placed lower down on the board under the heading "Engines out, week ending." At the end of the week these pegs are transferred to their proper place at the upper part of the board. The left-hand side of the board shows the condition for the east side of the shop, the white pegs at the lower right-hand corner being extra ones. In the centre of the board are shown the engines in the boiler shop; the engines on the hospital track; the engines to be shopped during the week and the engines that are held up for material. A few moments' study of this board shows the shop superintendent whether the work is being handled satisfactorily or not.

Application of the Individual Effort Method to Roundhouse Work.

Mr. J. F. Whiteford has had entire charge of roundhouse betterment work.

In applying the individual effort method to roundhouse work a time study was first made of the different operations concerned in wiping or hostlering different classes of locomotives. The following table, for instance, shows the number of units or cents which it was determined, as a result of this time study, would be a fair compensation for the different items.

Table of Units.	Coaled and Watered.	Wooded.	Sanded.	Fires Knocked.	Fires Cleaned.	Boilers Washed.	Boilers B. O.	Water Changed.	Flues Bored.	Wiped Freight.	Wiped Passenger.	Spkr. Hdld.	Front End.	Fires Built.	Turn Table.
01—0300.															
138—255..															
260—399..	7	2	5	18	12	65	5	30	12	25	45	8	10	8	3
1—137..															
2155—2418.															
400—502..															
564—788..															
2000—2034.	7	2	5	24	12	70	5	30	12	30	50	8	10	10	3
2100—2154.															

The total of each class of operations performed on each engine handled is multiplied by the cost as determined above, which total for all the engines handled will give the unit allowance for each roundhouse. The unit allowance for additional expenses is fixed arbitrarily at 30 per cent. of the

unit allowance of direct expense, except for points where there is no general expense charged. Comparing the expenses, based on such a time study, with the actual cost for wiping and hostlering gives the efficiency of this part of the roundhouse work.

All the operations in roundhouse work have been scheduled and given a standard time allowance. Comparing the actual time for all work with the standard time, the efficiency of a roundhouse may readily be obtained, and reports of this kind are actually being made each week for certain points where the work is being introduced. Following are a few items taken at random from the roundhouse schedule:

Subject.	Schedule No...	Description of Work.	No. of Men	Classes.	Time
Wiping	0074	Wiping tank frame and truck complete	1	All	0.4
Wiping	0068	Wiping machinery below runnng board inside of frames, including engine trucks, eccentrics, blades, straps, motion work and axles, inside surface of frames, rocker boxes, cylinders, saddles, brake rigging, also guides, rods and crossheads of balanced compound engines, lower part of jackets and all parts between frames not specified	1	ABCD FU ST	0.6 1.0 0.8
Air Work Governor	0130	Overhauling air pump governor complete	1	All	0.5
Rocker Boxes	1249	Tightening rocker boxes	1	All	0.3

If a man reaches the standard time as indicated in the schedule he is entitled to a 20 per cent. bonus; if a longer or shorter time is required the bonus is governed by the bonus curve, Fig. 34.

The following figures cover only the wiping and hostlering, and are for the A., T. & S. F. Proper. In January, 1906, 24,627 engines were handled at a total cost of $57,858.32, as against 25,849 engines handled in September of the same year at a cost of $47,263.01, or, in other words, 4.9 per cent. more engines were handled, at a cost of 18 per cent. less, in September than in January. The work in this department, however, has only been in effect a short time, and a fair comparison cannot be made until results are obtained extending over a greater period of time, and averaged to eliminate varying conditions. Judging from the results gained at one or two roundhouses which have been given special attention, the final results in improved efficiency and economy will be in line whith those already attained in other departments.

Application of the Individual Effort Method to the Car Department.

This work, under Mr. J. Epler, has only recently been placed in operation, and is conducted along somewhat similar lines to that of the roundhouse work. A schedule has been carefully drawn up for each operation in repairing cars, a standard time being designated for doing each piece of work. The amount of bonus paid is regulated according to the bonus curve, Fig. 34.

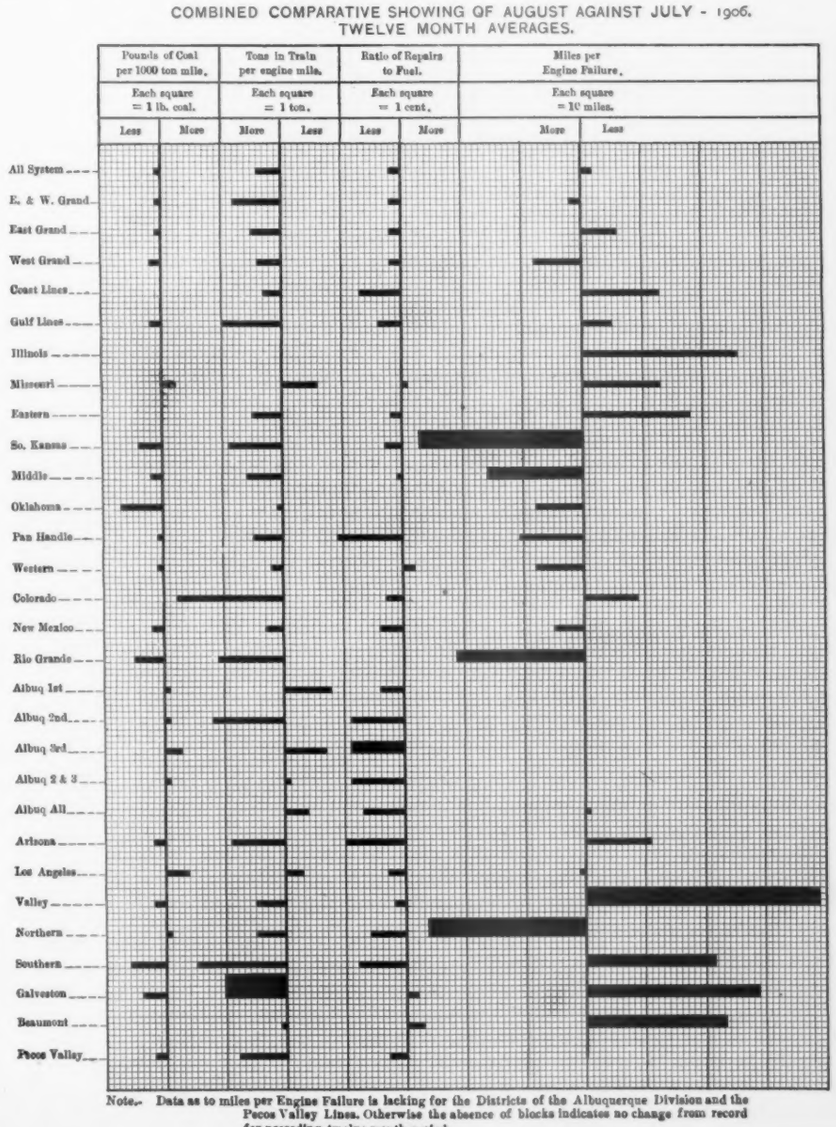
An improvement recently introduced at two of the car-repair points is to have the inspector carefully look over each car, see just what work is to be done and then refer to his schedule to determine the standard time in which the work should be completed, based upon the standard time for the various operations. The car is then turned over to the gang, and the bonus earned is divided among the members of the gang in proportion to their rate of wage.

Engine Equipments.

The matter of systematically looking after the engine equipments is an important one. The efficiency of the locomotive in service depends upon having these equipments in proper condition and very often a considerable amount of time is lost, due to some important tool or device not being on the engine when it is needed. There is also little question but what these engine equipments are a much greater expense to the company than they would be if systematically looked after, and in spite of this increased expense they are usually incomplete. Under the direction of the betterment department the Santa Fe has recently undertaken to systematically look after these equipments somewhat along the lines of the method in use upon the New York, New Haven & Hartford Railroad, which was described by Mr. Raffe Emerson, who is now under Mr. Jacobs and in charge of this work, on page 412 of our November, 1905, issue.

Power Plants.

Mr. C. B. Goode of the betterment force has had charge of improving the efficiency of the power plants. This work has consisted largely in reducing to a minimum the losses of steam due to leaks and radiation and to stopping leaks and correcting abuses in the use of compressed air. In several instances by improving the conditions, equipment which appeared to have insufficient capacity has been found to be entirely satisfactory and new equipment did not have to be ordered.



Note.- Data as to miles per Engine Failure is lacking for the Districts of the Albuquerque Division and the Pecos Valley Lines. Otherwise the absence of blocks indicates no change from record for preceding twelve month period.

FIG. 45.—COMPARATIVE ENGINE PERFORMANCE DIAGRAM.

Engine Performances.

A considerable improvement has been made as concerns fuel consumption, tonnage per train and engine failures. This has been done by forcibly directing the attention of the mechanical superintendents, master mechanics and road foremen of engines to the actual conditions and tendencies by means of diagrams similar to those shown in Figs. 2 and 3.

In addition to these diagrams showing the engine performances a comparative diagram is made each month based on twelve-month averages and showing the standing of each

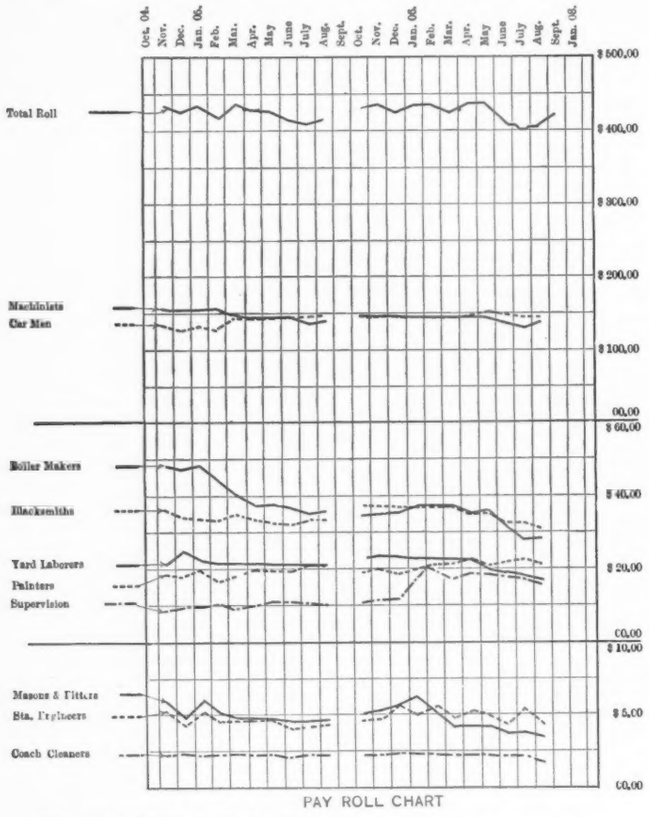


FIG. 46.—HOURLY PAY-ROLL CHART FOR TOPEKA SHOPS.

division as compared to its previous month's record. One of these diagrams is reproduced in Fig. 45.

In addition to these measures a member of the betterment force, Mr. T. W. Neely, who is a specialst on fuel oil burning, has for several months been at work on the Gulf Lines, introducing improved methods of oil burning, and gratifying results have been obtained. At the present time he is introducing his methods upon the Coast Lines, where the greatest amount of fuel oil is used on the system.

Graphical Check of Payrolls.

It is difficult to intelligently improve conditions if the figures concerning the operation of a department are not received until weeks later. One of the aims of the betterment department has been to have such figures available as quickly as possible and to furnish them to the mechanical superintendent, master mechanic, or shop superintendent, not only promptly but in such a form that they may readily be digested.

As an illustration, Figs. 46 and 47 show the payroll distribution of two shops. The one at Topeka is uniform and orderly, the other is confused and indicates a lack of system. These payroll records are based on the rate per hour to eliminate the variation between long and short months. At present all over the system the master mechanics are being furnished daily with the amount and distribution of their payrolls in order to check against the ideal figures. Also graphs of twelve-month averages are being furnished of grand division payrolls in proportion to train tonnage handled. This relation will show whether one division is relatively higher than another, or whether compared to traffic, shop expenses are going up or down.

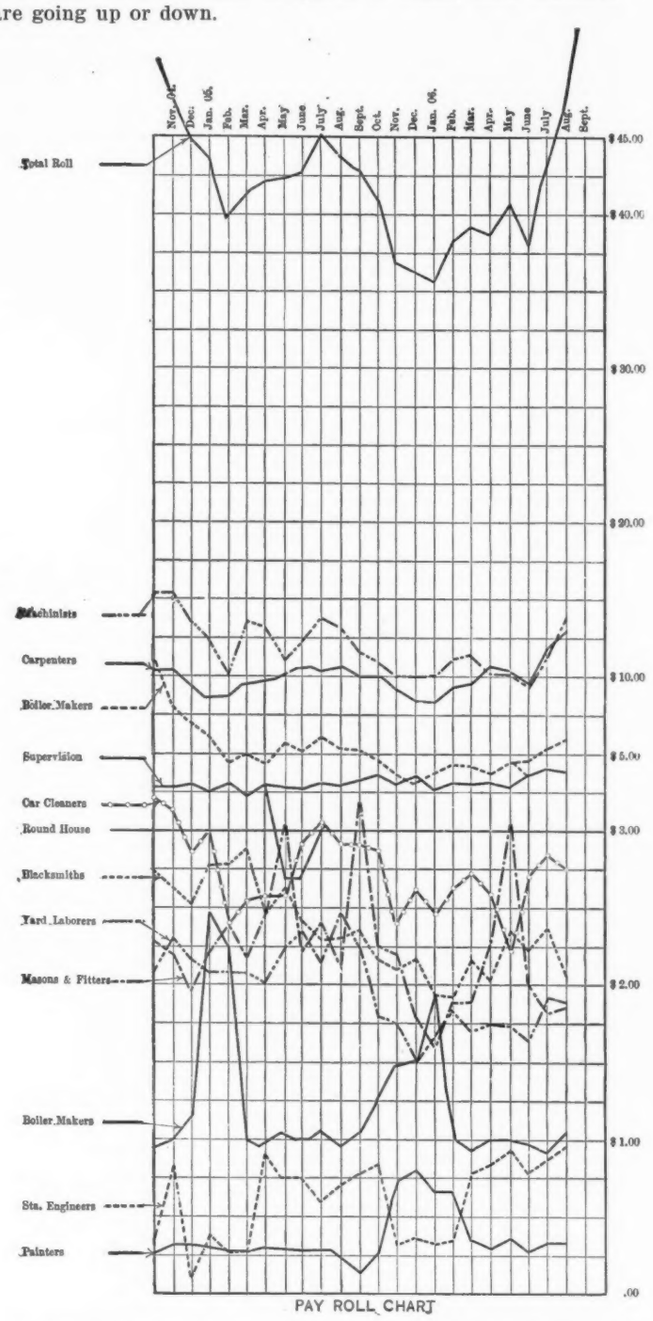


FIG. 47.—HOURLY PAY-ROLL CHART OF SHOP IN WHICH BETTERMENT METHODS HAVE NOT BEEN INTRODUCED.

Summary.

Betterment work means the highest efficiency at the right time and place at the lowest cost. Economy is never the aim sought for, but results indirectly and in fullest measure from the same methods which secure efficiency.

Betterment work affects beneficially every one connected with railroad work from the wage earner to the shareholder.

Usually the shareholder expects and demands certain results which through a long series of dilutions finally affect, and often unfavorably, the worker; hence reductions of force, reduction of pay and resulting enmity and strikes. The newer methods begin at the bottom, with the elementary operations, benefiting each man and as these are perfected efficiency grows from item to part, from part to whole, from whole to operation and with efficiency in, economy beginning in fractions of a cent saved on a minutes time swells through all the number of all the employes, benefitting each employe as it covers his work until in the end it swells into a mighty sum aggregating millions of dollars.

EFFECT OF BETTERMENT ON THE WORKMEN, OFFICIALS, AND OWNERS.

(1.) To the competent and reliable workman it brings the square deal, recognition of his individual ability and skill, increased pay, greater security of position.

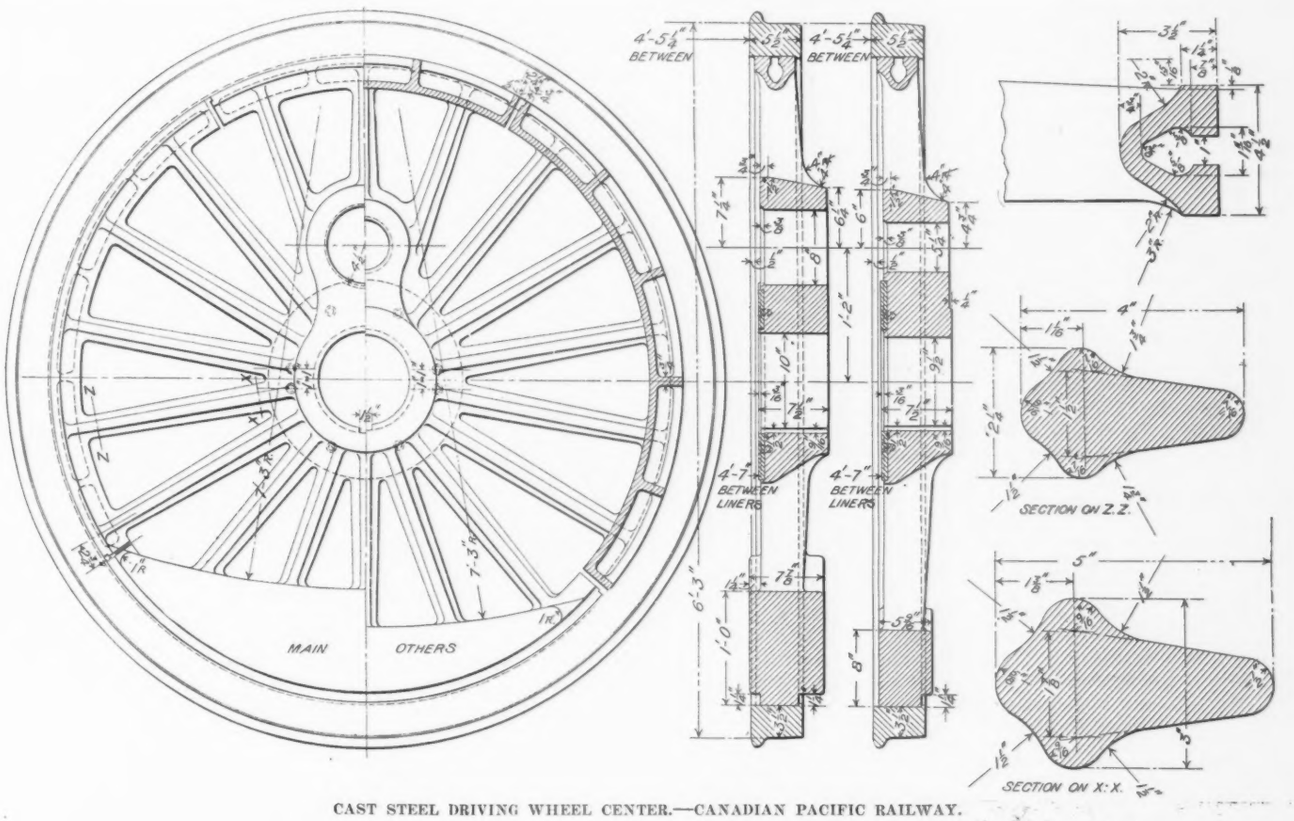
(2.) Of the foreman, no longer slave driver, it makes a planner, an inspector, an administrator, thus developing him and fitting him for a higher position and responsibilities, and the better he plans the higher his pay, not as a favor for which he must forever be subserviently grateful, but as a natural right due not to his personality but to his performance.

(3.) To the superintendent of shops or master mechanic it gives a body of loyal and efficient employes who are constantly helping, instead of hindering, and he is thus freed from time and energy absorbing detail. It gives him the facts on which to judge without personal bias or feeling, of the efficiency of every man, foreman, machine or operation.

(4.) To the higher official it will show in a single figure the efficiency of a shop in any given month, or at a glance show the efficiencies of any division as to all its important operations. It determines the relative economy of one engine type as against another. It is safe to say that with properly collated records in graphical form, each based on long intervals, the high official can in one hour a month ascertain better what is going on than he could formerly in days of surmise and uncertainty.

(5.) By means of the records boards of directors can intelligently approve of recommendations, and when a choice is forced act on what is essentially of greatest importance, the most important betterment rarely being the most obvious.

(6.) Finally shareholders as well as workers will benefit, the latter through their more intelligent and less wasteful efforts, the former through the aggregated and harmonized efficiencies and resultant economies of all operations.



CAST STEEL DRIVING WHEEL CENTER.—CANADIAN PACIFIC RAILWAY.

CAST STEEL DRIVING WHEEL CENTERS.

CANADIAN PACIFIC RAILWAY.

In connection with preparing the designs for Classes G1 and G2 Pacific type locomotives on the Canadian Pacific Railway, which designs were undertaken at the same time that standard parts were being adopted for these and other locomotives,* a 68-in. cast steel driving wheel center was designed, which contains a number of interesting features. While this design differs in some points from the recommendations of the committee on "tire shrinkage and the design of wheel centers," whose report was made at the last meeting of the American Railway Master Mechanics' Association, still it is in accordance with those recommendations in its main features.

It has 18 spokes, where the recommendations called for but 17, and has four shrinkage slots, which are fitted with cast iron filling blocks. In other respects, such as area of spokes at rim and hub, distance between inside faces of hubs, straight spokes, bearing area for tire, etc., it is in accordance with those recommendations. The shape of the spoke carries out the recommendations of the committee even further than the design shown in their report, and places a very large proportion of the metal directly below the tread of the tire, where it is of the most value, and, at the same time, the width of the spoke is made large enough to give the necessary stiffness. The rim is made in a hollow U-shape, which, while it gives sufficient bearing area, has its metal so placed as to give a better support to the tire between the spokes than if it was cast solid.

*See AMERICAN ENGINEER AND RAILROAD JOURNAL, 1906, pp. 126, 161, 212 and 388.

TEXT BOOKS NEEDED.—The instructors at the Winona Technical Institute, Indianapolis, Ind., find themselves handicapped for want of text books on the different trades being taught there. They say that the field of text book literature for trade schools is practically untouched and that such books should be written by men who have had practical training for long terms in shop service.—*Iron Age.*

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We owe our readers an explanation as to the delay in issuing this number. For the past two years or more we have been watching the progress of the betterment work on the Santa Fe System. The officials, however, did not feel that it would be wise to publish an account of this work until it had been given a sufficient trial to demonstrate clearly the results to be obtained. Mr. Kendrick and Mr. Lovell very kindly gave us permission to visit Topeka the early part of November and make a thorough study of what had been done. The results of our investigation were such that we felt that the matter was of too great importance to present serially, as is our usual custom with articles of any considerable length, or even to hold it for our January issue, and we have, therefore, taken the liberty of delaying the present issue in order to present the matter in a complete form at the earliest posible moment. The fact that so much space is devoted to one article in one issue is justified by its importance and the fact that it touches intimately on practically every interest in the mechanical department.

The growth of the different roads during the past few years and the combination of smaller roads into large systems has been so rapid that it is not surprising to find that matters of efficiency and economy have oft-times been overlooked. The time has come, however, when these matters must be investigated carefully. The situation on the Santa Fe in 1904, due to the labor troubles, was a serious one, and great credit is due to Mr. J. W. Kendrick, second vice-president, for taking such radical and successful measures for solving the difficulty and for improving the efficiency of the mechanical department. It is true that other roads have realized the need of betterment work, and in some instances have made considerable progress, but nowhere do we find such radical treatment or such striking results as on the Santa Fe. Whether the exact treatment used on the Santa Fe would give equally good results on other systems may be questioned, but there can be no question but what the general principles used by Mr. Emerson in his work on the Santa Fe are equally well suited for conditions on other railroads in either the motive power or other departments.

THE SURCHARGE PROBLEM.*

TO THE EDITOR:

Have read the comments on the Surcharge Problem in your issue for November, 1906, with great interest.

Mr. Theo. F. H. Zealand voices a very obvious yet untenable objection. It is true that if a shop contains two machines whose output has to carry all the expenses, and if one of them is shut down the other will have to carry double load. When, however, railroad shops all over the country are expanding, adding to their equipment, and installing new machines the objection does not apply. One of two courses is necessary, either to add to present equipment and proportionately bring up the surcharge, or to buy on the outside those articles which are not economically manufactured in a railroad shop.

It is also easy to fall into the error of confounding surcharge with cost. If a shop has ten men and a surcharge of 80 per cent. on their wages, and can manage to do the same work with five men and a surcharge of 160 per cent. on their wages, the output is cheapened in spite of increased surcharge.

"Shop Superintendent" is also filled with skepticism. The facts are:

(1). That it takes some little time to determine the proper machine rates and surcharges to each department, although at a pinch they could be done with all needful accuracy in a fairly large shop in a very few days.

(2). That after this initial work is once done it takes neither clerical force nor any appreciable time to determine the actual cost of any single article.

(3). That cost need have no connection with accounting. A railroad may give away its manufactured material if it so elects, or it may sell it for twice its cost if it can find a customer, neither of these actions having any bearing on the question of cost determination which remains the same whether any accounts are kept, or articles are given away or sold for high profit.

(4). Finally it is possible in a shop turning out 360 locomotives, to determine with extreme accuracy and *in advance* the cost of every operation, or collection of operations and this with very little clerical force. In the shop in which Mr. Morrison holds an important position, the cost of repairing each locomotive is determined largely through his work, before any work is begun and on an average within 3 per cent. of accuracy.

H. EMERSON.

Topeka, Kan.

* [For information concerning the application of surcharges at the Topeka shops see page 469.]

To the Editor:

The interesting article on the Surcharge Problem, by Mr. C. J. Morrison, and the editorial regarding it in your October journal, also the letters on the same subject in the November journal, are of great interest to all persons interested in economical shop management, as it is only by becoming acquainted with the cost of doing work that the best results may be obtained, and while everyone may not be able to carry out this matter to the extent advocated, still, if given proper attention, it will result in a saving of money for our employers.

As stated by Mr. Morrison, more attention will be given to requests for new high-power machinery, when the person requesting it is able to demonstrate the resulting economy, and it will also frequently deter the asking when the actual saving to be obtained is figured up in dollars and cents.

Another result is that, if this surcharge is followed up closely, and especially by machine foremen, it will result in the keeping of each machine in constant use and the dispensing with machines that are unnecessary and seldom used.

I do not agree with Mr. Morrison that in all cases it is cheaper to buy, when the cost of manufacturing in railroad shops is greater than the market price. It is frequently necessary to manufacture material as a filler in order to keep men and machines busy, and the cost of this work, owing to the number of times it has to be laid aside, is apt to make the price excessive; yet, at the same time, it is economical for the company to do it, and the reasons for the price being high should be given due consideration.

Shop surcharge and cost of manufacturing can be materially reduced by properly locating the point of manufacture, which, in most cases, should be at main shops. When it is not expedient to do all of it there, the outside shops should each have their special line, so as to save unnecessary duplicating of expensive machinery, and also to give opportunity for the use of jigs and special appliances which would not be economical when only limited quantities are made. The proper grouping and locating of machines, to avoid unnecessary handling, will also be found to be a very important factor in cheap production.

The difficulty of getting accurate costs of manufactured material in railroad shops is admitted by all. In most cases, it is not entirely the fault of the accounting department, but is frequently due to the improper charging of time by workmen. This is especially true where the same men do repair work.

I fully agree with Mr. Morrison regarding the advisability of sometimes raising the wage rate in order to increase the output, but in most cases this is impossible, owing to agreements with labor organizations, as the minimum rate is also the maximum.

It seems that, with sufficient thought regarding cost and surcharge and proper supervision, there should be no reason why the larger part of the material entering into construction and repairs cannot be manufactured in railroad shops in competition with outside firms when used in sufficient quantities to enable economical manufacture.

Mr. Morrison's statement that too much stress is put on the pay-roll may be true, but if this was not so it would likely lead to extravagance, and it is doubtful if the time will come when this will not receive the first consideration by officials, and I do not see how, when reductions have to be made, it could be done on the amount of surcharge, as this is comparatively a fixed charge when once established.

CHARLES COLEMAN,
General Foreman C. & N. W. Ry.

WINONA, Minn.

TO THE EDITOR:

On page 438 of the November issue appear several communications on "The Surcharge Problem," which show that considerable thought is being given to the subject. It is a very complicated subject and one that can hardly be grasped in a single reading. Perhaps weeks of preliminary work will have to be done before the surcharge can be figured for a simple shop.

Mr. Zealand's point of view of closing one department, and doing no other work is a phase I did not consider because of the fact that at present nearly every shop in the country is crowded with work, and as soon as they cease to manufacture one article they start in on another. However the idea of closing the plant is worth considering. Suppose we consider an extreme case and close an entire plant, but do not dispose of any of the equipment. Class 1 (page 376, October issue) would be effected only in D, which would be reduced to a very small figure, and Class 1, would probably be 6.5 per cent. Of Class 2, the watchman only would remain. Of Class 3, A would drop to 2 per cent., 2—B would remain unchanged, while the other items would become zero. Of Class 4—A, B and D are unchanged, while C becomes, 4 per cent., and the other items zero. Our total surcharge on a fully equipped plant standing idle is, therefore, expressed as a percentage of the former pay-roll:

1.	Rent.	
	A	1.8
	B	1.8
	C	.6
	D	.3
	E	.6
	F	1.4
2.	Supervisory and Miscellaneous.	
	A-B-C-D	.0
	E	.4
3.	Machinery.	
	A	2.0
	B	1.5
	C-D-E-F-G	.0
4.	Power.	
	A	.2
	B	.2
	C	.4
	D	.2
	E-F-G-H-I	.0
	Total	11.4

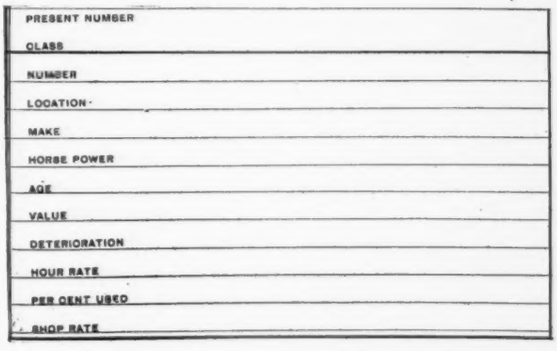
The surcharge of 11.4 per cent. of the former pay-roll would, of course, still have to be cared for and would be added to the cost of the purchased articles.

Mr. Zealand misses the point when he states that the surcharge would not be effected by the manufacture or discontinuance of manufacture of a given article. The surcharges are there and must be taken care of. The surest way to reduce the surcharge on any particular item is to produce more of that article in a given time.

Another way to reduce the surcharge percentage is to work 720 shifts per year instead of 300. In fact the surcharge would make certain plants unprofitable if they were unable to work nights as well as days.

In many instances a careful study of the surcharge will show certain items to be abnormally high. These items can then be given attention and reduced. I have in mind a case where a reduction of 2-D (Spoiled Work), page 376, October issue, saved a firm from going to the wall. In another case moving certain portions of the work, made a large reduction in 1-E (Insurance).

In answer to "Shop Superintendent" I would state that a railroad repair shop handling 360 engines a year and manufacturing for a large system installed the system as outlined without the addition of a single man to the force. Whenever questions of new machinery, of purchasing articles, of making new parts instead of repairing old, of manufacturing at other points on the



system instead of at this point, etc., come up the surcharges are carefully studied. A card is kept for each machine, as shown above and the machine foremen know the rates of the machines as well as the rates of the men, and assign work not only with the idea of the man's rate but also of the machine's.

This prevents high-priced machines from being loaded with work that could be done just as quickly on an old low-priced machine, and at the same time prevents the low-priced machines being assigned work that they are not capable of doing as cheaply as the higher priced machines on account of the longer time consumed.

The first step in installing the above system was to determine the surcharge for the plant as a whole, as outlined on page 376 of the October issue. The original cost of the buildings and machinery was obtained and the value at the present time was estimated, then the rates of interest and depreciation were assumed. Other items were for the most part obtained from the accounts, but not without considerable work, and in a few cases it was necessary to estimate them.

The second step was to divide the charges between the locomotive and car departments.

The third step was to distribute the charges among the different departments; for instance, let us consider the locomotive de-

partment. Each shop, such as pattern, forge, tin, machine, etc., has a specific surcharge. Item 1, rent, was apportioned according to the building and ground occupied. Item 2A (supervision and office), was apportioned largely by estimate, as just how much time the superintendent of motive power, mechanical engineer and others of the higher officials give to each department is unknown; B (accounting) was apportioned in proportion to the number of men; C (drawing room) according to the new drawings used by each department per month; D (spoiled work) was at first estimated, but was afterwards determined exactly: E (laborers) according to the work done for each department, and watchmen, according to the space covered. At first 3 A, B, C, D (machinery—depreciation, interest and repairs) were distributed according to the valuation of the machines, and E, F, G (replacing small tools, tool steel and supplies) were estimated for each department, but afterwards the accounts were kept so that these charges for each department were known.

A recording ammeter was placed for a week at a time on the different motors, and the cost of the power actually used was charged. Heat was apportioned according to the building occupied; light according to the number of lights and the hours which they burned; the water used was estimated. The air compressors were carded and the air used by each department measured. The hydraulic pump engines were also carded.

This gives the total surcharge for any one department. The next step is to divide the charge between the men and the machines. Item 1 (rent) was arbitrarily apportioned, half to the men and half to the machines. Of item 2 (supervising and miscellaneous) the machines get a very small percentage, probably 10 per cent. of each charge, except D (laborers and watchmen), all of which goes to the men. Item 3 (machinery), except G and E (supplies and replacing small tools), is divided between the men and the machines in proportion to the value of the machines to tools and machines used solely by the men, such as elevators, air hammers, cranes, etc. In the crane charge an exception is made in the case of cranes which serve only one machine and are virtually a part of that machine, in which case they are charged against the machine. E (replacing small tools) is carried entirely by the men, and G (supplies) by the machines.

Item 4 (power, heat, light, water, etc.) is apportioned according to the power used to run the machines and the power used for the convenience of the men. Light and heat are charged entirely to the men, while water is charged partly to the machines.

We now have the charges divided against the men and the machines. The surcharge on the men in any department is applied as a percentage of the payroll, while the surcharge on the machines is applied as an hourly rate. At first the machines were charged in proportion to their valuation, and the number of hours run per year were estimated. Later, when the accounting the actual power it used, paid for its belts, etc. Of course, made it possible, each machine was charged according to its actual expenses. Thus a machine paid rent for its shop room, paid for in the case of machines in groups it was necessary to estimate the power used by any one machine. The accounts also show the hours which each machine runs. Thus the surcharges are brought down to figures as nearly exact as any charge of this nature can ever be.

Of course, some one else may divide the charges differently between the men and the machines, or between the different departments. Some of the divisions are largely a matter of judgment, and would, of course, be different in different shops. The real point is to be able to determine exactly how much any particular article costs. The exact method of determining this cost is immaterial as long as the result is accurate.

It is true, as "Shop Superintendent" states, that the accounts on many railroads are kept in such a way that some of the items comprising the surcharges would be difficult to obtain, and some of the items may have to be estimated the first time. However the surcharges must be revised from time to time, and the method of accounting can easily be altered to give the necessary information. For example, in the shop with which I am connected, repairs to machinery, which were formerly charged to a general account, are now charged to the individual machines by number. Hand tools are no longer charged to a general account, but to the department using them. A recording ammeter, placed for a week at a time on the different motors gave the current consumed by each. Thus we find ourselves able to tell the exact surcharge on any machine or any department without estimates entering into the calculation. The only opportunity of error is that during 1907 we will make the shop earn the 1906 expenses. In case the 1907 expenses go higher than the 1906 we are to the bad, but in case they run lower we have just that much on the profit side to use for improvements or new machinery. With careful management only some very unusual circumstance will cause the expenses to change enough to seriously affect the surcharges.

I wish to ask a question which may show the value of the surcharge study. A large number of railroads are building locomotives. How many of these roads know, not guess but know, whether they are building these locomotives at a profit or a loss?

C. J. MORRISON.

Topeka, Kan.

THE DRAFT GEAR SITUATION.

TO THE EDITOR:

I have read with a great deal of interest the communication signed "A Rail Roader," published in your November, 1906, issue on the subject of the draft gear situation, and while I am an ex-railroader, and not identified with the business at this time, I am going to make a suggestion or two that possibly may answer some of the questions asked by your correspondent.

The inquiry of a railroader, "If the friction gear has so many advantages, why is it that it is not more generally used," might be answered by him and every other railroad man if introspection was used instead of inquiry. The interesting fact is that by instinct and education all railroads object to changes in their present practices, or improvements in their general equipment. This was true in regard to the air brake, the vertical plane coupler, and everything else that has been brought out for the improvement of railroad practice in the last quarter of a century. Nothing new is ever presented to a railroad, however meritorious it may be, that is not condemned at once, and is only placed in service after a long and expensive fight by the manufacturers, often resulting in bankruptcy of the inventor and the manufacturer before the device is recognized. It is not necessary to particularize this statement, as every railroad man and manufacturer can conjure up from his memory many cases that fit this statement.

There are also many railroad men in the United States that are opposed to everything that has been invented that is contrary to the practice of the railroad when they went into the service. One manufacturer of a draft gear told me a short time ago that in conversation with a Master Car Builder of one of our principal lines, who had been in service almost if not quite a half century, the subject of service strains was brought up, and to the statement of the manufacturer that the ordinary spring gear was recognized now as inadequate to the demands, the Master Car Builder replied that that could not be true. The manufacturer says that he brought up the dynamometer car test in support of his statement, but this was brushed aside by the Master Car Builder with the statement that he had been in the car business a long number of years, and therefore, he certainly knew. There are a great many railroad men who take this position; that is, that their long years of service in the car business makes them a better judge of the requirements of railroads and railway cars than any test that could be made by improved indicating machinery.

Another case related to me by a manufacturer of draft gear had to do with another very prominent railway system, where the device had been solicited for a laboratory test, and was sent of course. After several months the device was returned to the manufacturer with a statement that the *test developed the fact that it could not be used on this particular railroad on account of the cost.* It developed afterwards that no test had been made of the device.

There are other instances that could be related, but these two about cover, in my estimation, the proper answer to your correspondent's inquiry; that is, that the friction draft gear is not more generally used because of the prejudice existing against any improvements whatever by railroads in general on account of preconceived notions of service values born years and years ago, and, second, because there is a prejudice against using anything on a railroad, however meritorious it may be and however much it may save the car structures in the long run, if the device itself costs more than the cheapest thing that can be bought.

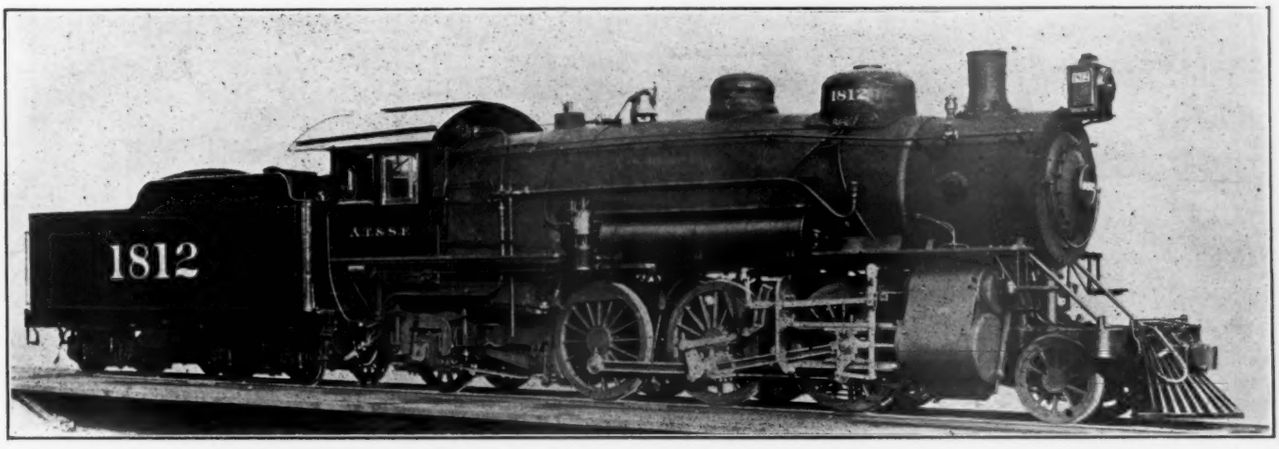
There is no question in my mind but that the manufacturers of draft gear, taking them all into consideration, have produced and are offering to the railroads, devices that are materially beneficial to the car people of the United States, and it is up to the car people to pass upon their merits and to act.

The suggestion of your correspondent that the Master Car Builder's Association take up the question of testing draft gear

seems to me to be a superfluous one, inasmuch as your correspondent himself mentions the fact that this subject was very thoroughly covered in 1902. The tests made by the Western Railway Club and by the Master Car Builder's Association in 1902, which tests have been pretty thoroughly published, seem to me to cover the case, and it would be useless to go into the subject any further in this way. There have been within the past two years additional tests of draft gear made by several railroads, and the results of these have been so confusing that it was difficult if not impossible to tell which, if any, of the draft gears tested came out best, and this would be the result of every other individual test made by a railroad, except in actual service.

I cannot understand what your correspondent means by saying that whereas the advantages of friction draft gear are usually stated in general terms they have not been reduced to a dollar-and-cent basis. If this is true in the case of your correspondent, the commercial engineers of the draft gear business must have changed their practice very materially since I went out of service, for I am quite sure that all of these gentlemen that visited me had this proposition reduced to a comparative basis as to cost and maintenance, and I believe that if your correspondent wants to get this kind of a comparison he can do so very quickly by taking the subject up with any of the manufacturers of a friction device.

New York, N. Y. X. R. R.



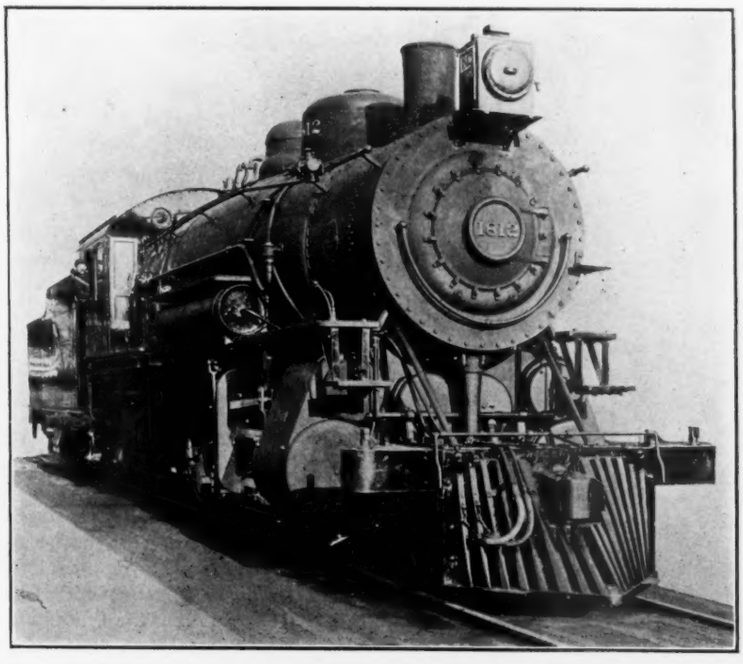
BALANCED COMPOUND LOCOMOTIVE WITH INCLINED HIGH PRESSURE CYLINDERS.—A., T. & S. F. RY.

FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE WITH INCLINED HIGH PRESSURE CYLINDERS.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

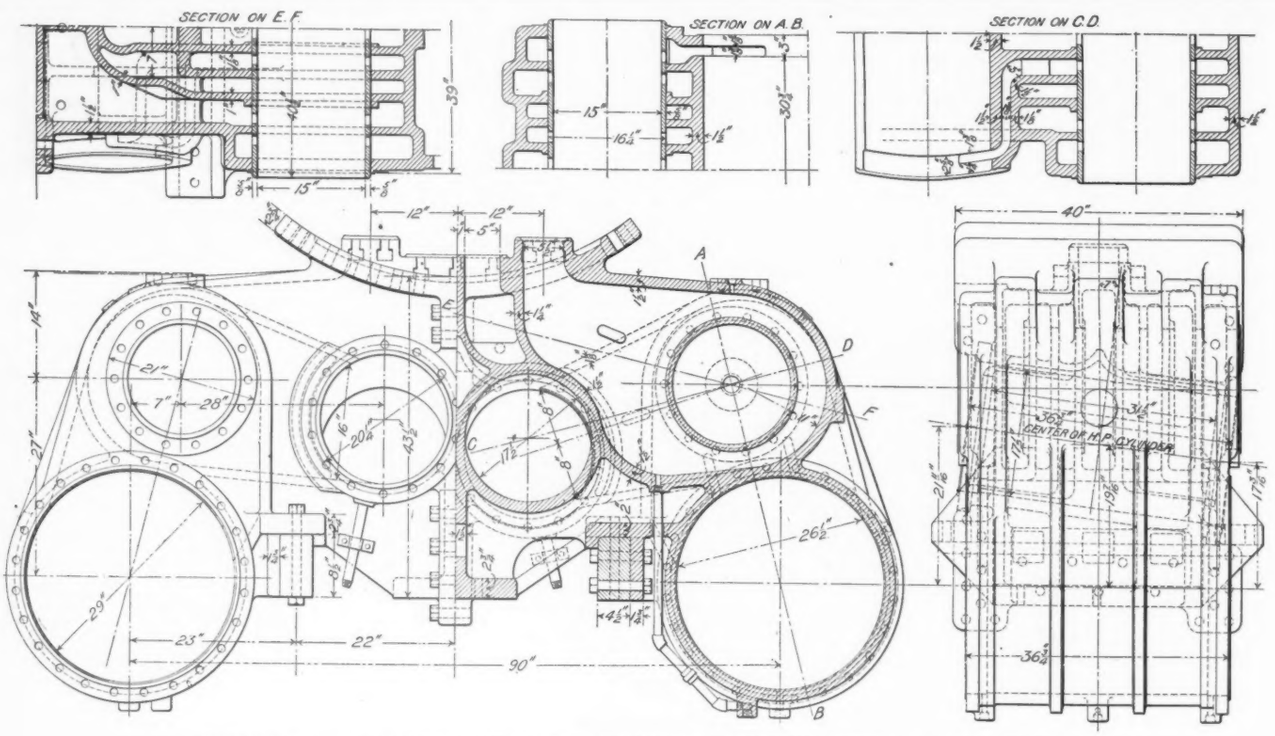
On page 434 of the November issue of this journal was illustrated and described a very large and powerful Prairie type locomotive, an order of which was recently built by the Baldwin Locomotive Works for the Atchison, Topeka & Santa Fe Railway. At that time were shown the general elevations of the locomotive, and the interesting numerical computation for obtaining the proper counterbalance weights to be placed in the driving wheels, which weights, due to the inclination of the high pressure cylinders, were found to vary nearly 500 lbs. between the two main driving wheels on the same axle. We are now able to show photographic illustrations and other details of these powerful locomotives.

As mentioned in the previous article, the raising and inclination of the high-pressure cylinders for the purpose of having the inside main rod pass over the front driving axle and connect to the second cranked axle introduces no particular complication outside of the cylinders and counterbalance. A study of the illustrations of the cylinders given herewith will show how the ports and connections between the valve chamber and the two cylinders, whose centre lines are not in the same horizontal plane have been arranged. This is the largest four-cylinder balanced compound locomotive ever built, and for the purpose of giving sufficient port openings to furnish a 17½-in. high-pressure cylinder with steam a 15-in. hollow piston valve has been used, which, together with its bushing, is also illustrated. It will be seen that the passages in the cylinder casting have been made in all cases as liberal and direct as possible. The passage from the valve chamber to the high-pressure cylinder is the one which has the most tortuous route to follow, since the admission is from the centre of the valve. As the passage to one of the cylinders must necessarily come from near the centre of the valve chamber, it is advisable to make this the high-pressure passage in preference to the low-pressure, because of a quicker movement and less volume of the high-pressure steam, outside of other considerations.



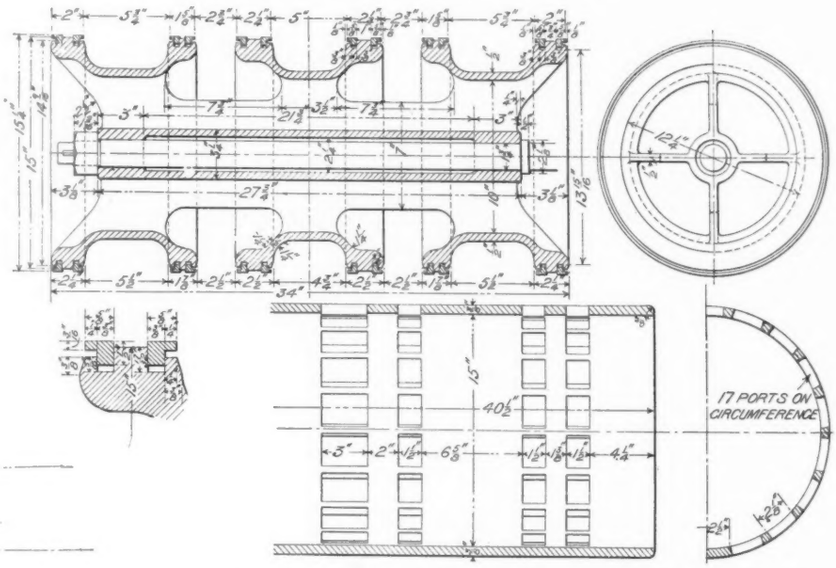
VIEW SHOWING CYLINDERS OF BALANCED COMPOUND LOCOMOTIVE.
A., T. & S. F. RY.

The illustration clearly shows the details of the single piston valve, having six sets of packing rings which control the steam for both cylinders. It will be noticed that the port openings through the bushings are 1½ ins. wide in all cases, except the live steam admission port, which is 3 ins. wide. This gives 108 1-3 sq. in. port opening for admission to the valve chamber and 54.2 sq. in. area for a full port opening into either of the cylinders and to the exhaust.

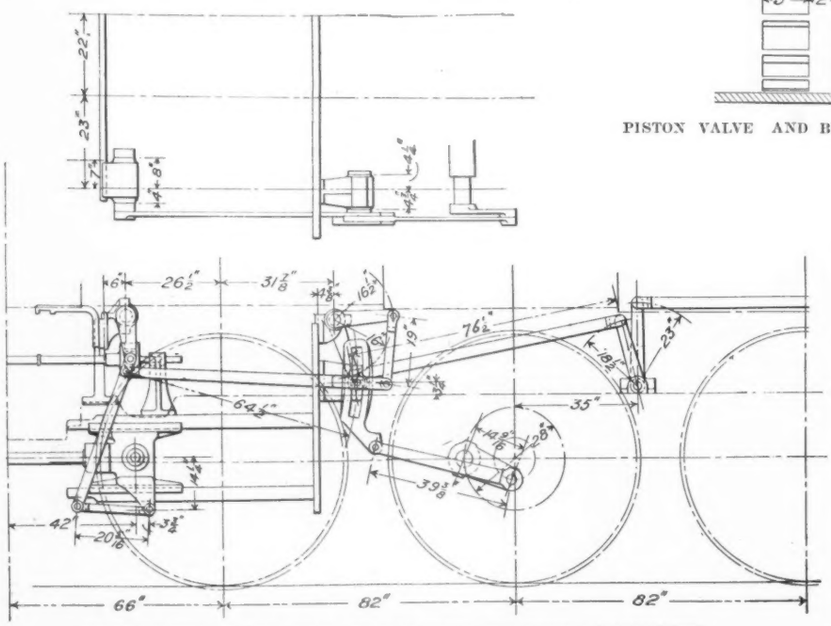


CYLINDERS OF BALANCED COMPOUND LOCOMOTIVE.—ATCHISON, TOPEKA & SANTA FE RY.

In the design of the Walschaert valve gear as applied to a balanced compound locomotive, it is unadvisable to place the valve chamber in a position to have the whole motion in practically one vertical plane, as can be done with a simple engine, and hence the motion is transmitted from the top of the combination lever to a rocker arm, supported just back of the cylinders, the inside arm of which operates the valve rod through a crosshead connection. The illustration shows the method of connecting the reverse mechanism, which employs two reverse shafts, one placed just above the link and supported from the guide yoke, and the other on the frame back of the main drivers.



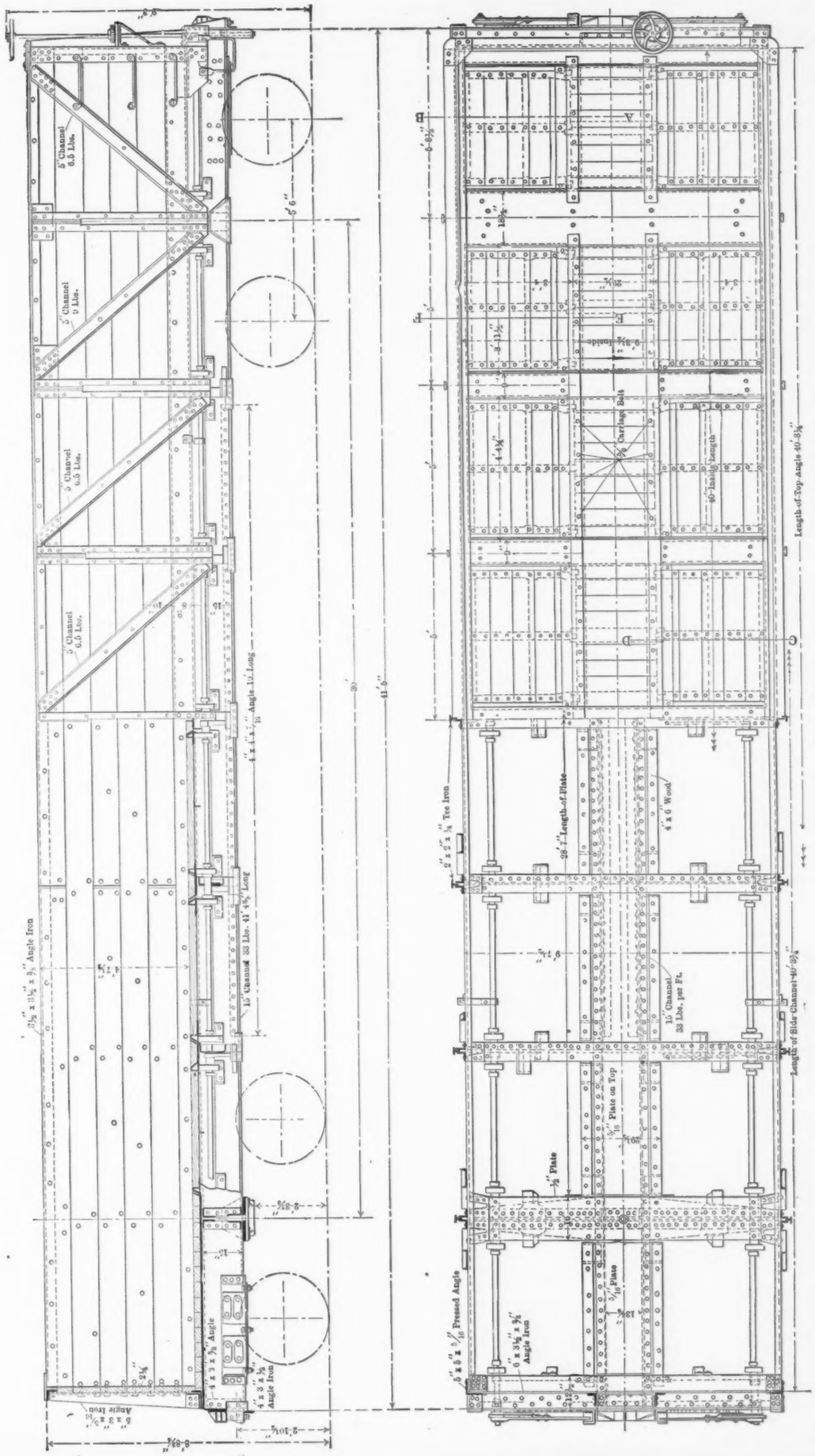
PISTON VALVE AND BUSHING, BALANCED COMPOUND LOCOMOTIVE.



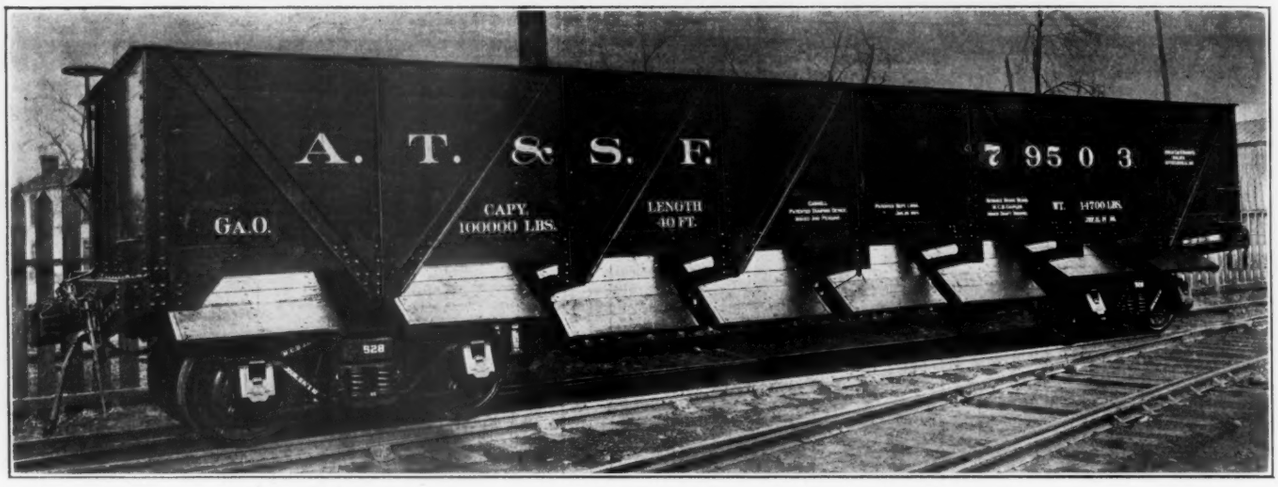
WALSCHAERT VALVE GEAR ON BALANCED COMPOUND LOCOMOTIVE.

HARDER CAR WHEEL CHILLS.—A United States patent has recently been issued for the treatment of car-wheel iron in the ladle with powdered Rutile, the chief ore of titanium, for the purpose of increasing the hardness of the chilled tread.

Railroads in Oklahoma.—When the new State of Oklahoma is admitted to the Union next May it is estimated that it will have 6,000 miles of railroad in operation. It has 3,000 miles now, and 3,000 miles more are expected to be completed by June 1, 1907. It is believed that no other State ever came into the Union with such extensive transportation facilities.—*Iron Age.*



50-TON STEEL FRAME GONDOLA CAR.—ATCHISON, TOPEKA & SANTA FE RAILWAY.



50-TON STEEL FRAME GONDOLA CAR.—SANTA FE SYSTEM.

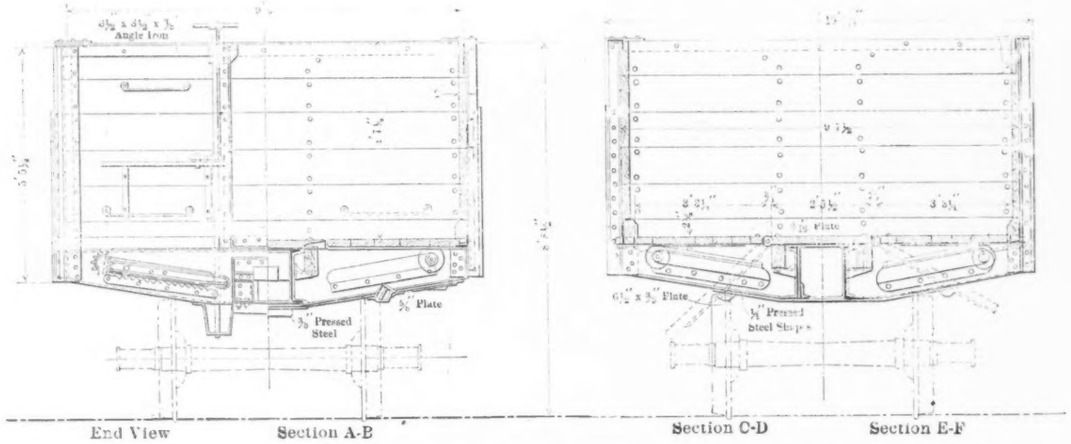
50-TON STEEL FRAME GONDOLA CAR.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

The 40 ft. steel frame gondola cars, 100,000 lbs. capacity, illustrated herewith, have been in service on the Santa Fe for about a year and were built at the Jeffersonville works of the American Car & Foundry Company. They are used largely for hauling coal, gravel and rock ballast and are equipped with 16 drop doors operated by what is known as a Santa Fe modification of the Caswell drop door mechanism, similar to that used on the steel underframe stock and coke cars described on page 417 of our November issue. They weigh 44,700 lbs. each and have the following general dimensions:

Length over end sills	41 ft. 5	ins.
Length inside	40 ft.	
Width over stakes	10 ft. 2⅝	ins.
Width over sideboards	9 ft. 7½	ins.
Width inside	9 ft. 3½	ins.
Height inside of box	4 ft. 7¼	ins.
Height, top of rail to top of sideboard	8 ft. 8½	ins.
Height, top of rail to top of brake staff	9 ft. 3	ins.
Wheel base of car	35 ft. 6	ins.
Wheel base of truck	5 ft. 6	ins.
Distance between truck centers	30 ft.	

The centre sills consist of 15 in., 33 lb., channels reinforced for 19 ft. at the centre by 4 x 4 x 7-16 in. angles riveted to the inside of the webs at the bottom. They are also reinforced by a 5-16 in. cover plate. The side sills are 8 in., 11¼ lb., channels. The cross ties are of pressed steel ¼ in. thick with 3¼ in. flanges. They are reinforced at the top with a 5-16 x 6½ in. plate and at the bottom by a ⅜ x 6½ in. plate, these plates extending the full width of the car and securely tying the various parts together, as shown in the illustrations.



PART END VIEW AND CROSS-SECTIONS OF SANTA FE GONDOLA CAR.

The members of the body bolster are of pressed steel with 3½ in. flanges. They are securely riveted to the centre sills and are tied together by a ½ in. plate at the top and a ⅝ in. plate at the bottom. The end sills are of pressed steel 5-16 in. thick and are reinforced with a heavy angle at the top. They are securely attached to the centre sills as shown on the drawing. The dead blocks are of malleable iron. Miner tandem draft gear is used.

The floor supports are of yellow pine and are secured to the centre sills by malleable iron brackets. The flooring is 2¼ ins. thick. The side stakes are built up of 3 x 3 x 5-16 in. angles and 2 x 2 x ¼ in. T's. They are riveted to the side channels, to the gusset plates and to the top side angle. The side braces are 5 in., 6½ lb., channels except the first and intermediate, which are 9 lbs. to a foot. These braces are riveted to the gusset plates, the side channels and to the 3½ x 3½ x ⅜ in. top side angle. The end stakes are 3 x 5 x 5-16 in. angles and are secured at the bottom with ¼ x 5 in. bent steel plates and at the top to 5 x 8½ x ¼ in. gusset plates and to the 3½ x 3½ x ⅜ in. top angle. The corner bands are 5 x 5 x 5-16 in. angles. The side boards are 2 x 10 in.

We are indebted for information and drawings to Mr. A. Lovell, superintendent of motive power, and Mr. E. Posson, engineer of car construction.

PROPOSAL TO MAKE POST OFFICE PRIVATE CONCERN.—Mr. W. D. Boyce, of Chicago, has made a proposal to the Postal Commission to take over the post office business, operate it as a private corporation under full Government regulation and reduce by one-half all postal rates, establish rural postal express and apply business methods throughout.

THE TUNNEL UNDER CAPITOL HILL at Washington, by which the Pennsylvania Railroad will reach the new union station has been completed. This tunnel is 4,033 ft. long and consists

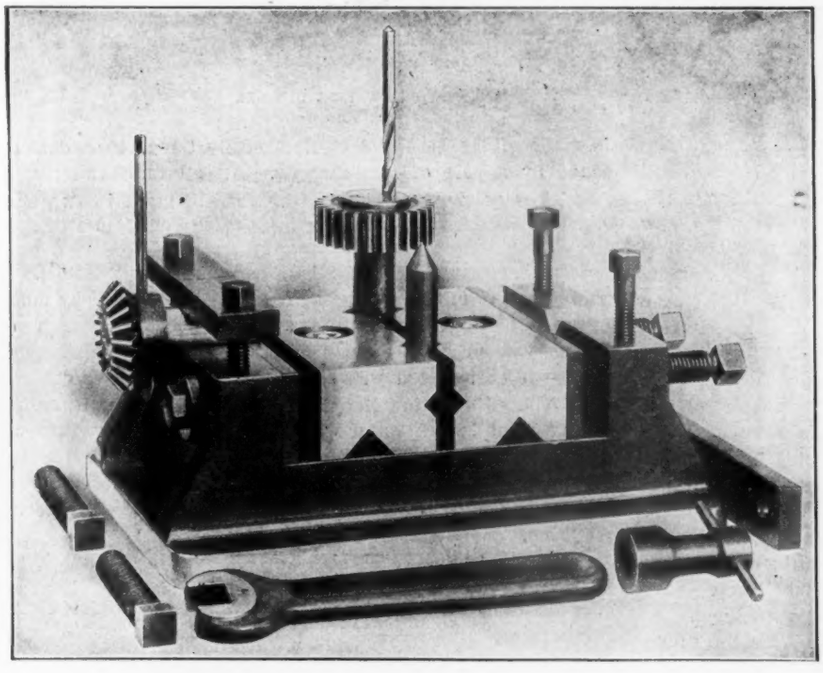
of two tubes separated by a masonry wall, each tube carrying a single track. Through this tunnel, trains to and from the South will secure direct communication with the new terminal station.

PHOTOGRAPHIC CARS for use of official photographers have been introduced upon the Southern Pacific Railroad. Each provides professional equipment and living rooms for four photographers.

AUTOMOBILE RACING.—The international automobile race for the Vanderbilt Cup, which was run over a course on Long Island on the morning of October 6, was won by Wagner, driving a French built car. The ten rounds of the circuit, which made 297.1 miles, were run in 290.1 minutes, giving an average speed of 61.42 miles per hour. No American built car finished, but the fastest single round was made by Tracy in a Locomobile.

DRILL PRESS CHUCK.

A very convenient and useful chuck adapted for use with drill presses, milling machines, shapers and planers, has recently been placed on the market by the Cincinnati Machine Tool Company, Cincinnati, O. The chuck will hold flat, round, straight or taper work equally well, adjusting itself to the shape of the work and holding it securely. The steel blocks used in the chuck are planed from bar machinery steel, and have different sizes of V's planed true and square at different angles. These blocks may readily be removed by passing the heads of the clamping screws through T slots in the body of the chuck. This allows the blocks to be used as regular V or parallel blocks. The steel jaws attached to the body of the chuck may be removed by taking out the hexagon head screws



CHUCK FOR DRILL PRESSES, MILLING MACHINES, SHAPERS, ETC.

and the large screws, shown at the end of the chuck may be inserted and used for holding rough work, thus keeping the jaws in good condition for the finer class of work. The flange around the body of the chuck is planed true and square with the jaws for convenience in setting and clamping on the machine. The No. 3 chuck, now ready for delivery, is 6 ins. wide and 1 11/16 ins. deep. It will open two inches with both blocks in place; 4 ins. with one block and 6 ins. with both blocks removed. It weighs 45 lbs.

A NEW FLEXIBLE STAY-BOLT.

The question of using flexible staybolts in certain sections of locomotive fireboxes is one which has been particularly prominent since the general introduction of the large high-pressure modern boiler during the past few years. It was condensed and clarified to a large extent by the report of the committee appointed by the American Railway Master Mechanics' Association to investigate the subject, which was presented at the last convention. This committee had made extensive experi-

NEW FLEXIBLE STAYBOLT.

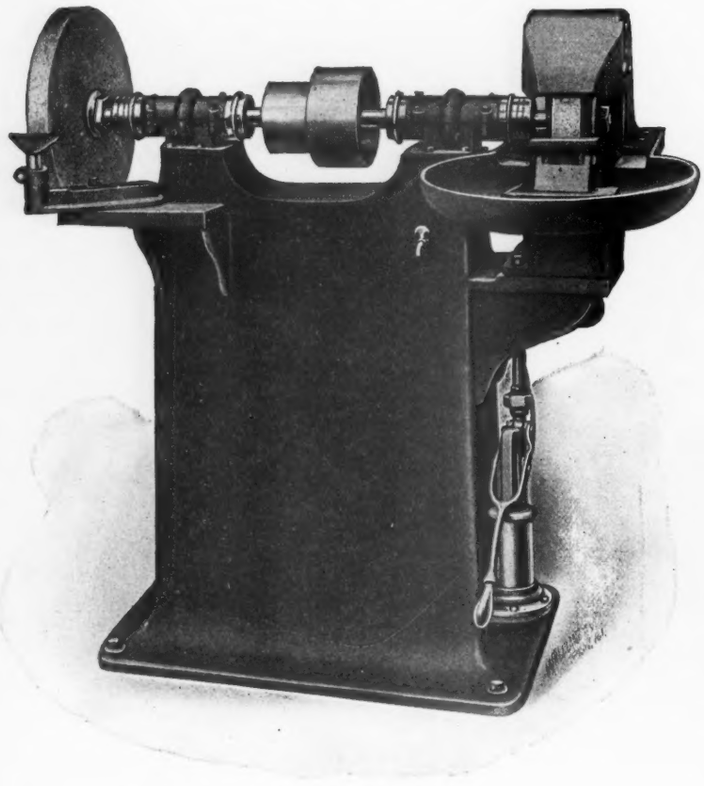
ments and clearly showed that there was a decided movement of the two sheets of the firebox relative to each other, which movement varied widely at different points in the firebox and under different firing conditions. The report also stated that the flexible stay-bolts then in use were successful when of the proper design and that their use had resulted in a big improvement in boiler conditions. The principal condition which defeated their purpose was the use of water giving a hard scale, and the importance of this point has been largely nullified by the improvements in design of the later types of flexible stay-bolts.

Since the report of this committee was presented an entirely new design of flexible staybolt has been patented which is distinctly different from the most successful of the previous types, in that it employs the principle of the eye bolt for its flexibility instead of a ball-and-socket joint. This bolt, which is illustrated herewith, is being placed on the market by The Flexible Bolt Company, 42 Broadway, New York, and consists of a drop-forged, mild steel eye head, through which a round rod of stay-bolt iron is passed and bent into a U shape. The center of this U. above the eye is then filled by a special shaped piece of iron and the three pieces are heated to a welding heat and forged down to 1 in. in diameter, care being taken that the connection at the eye is kept cool during this operation. This gives a bolt which has free latitudinal movement for a sufficient distance to answer all purposes, but is so constructed that there is practically no lost motion longitudinally. The eye, or head, section is then threaded with a taper thread and the opposite end with a standard stay-bolt thread, the two threads being cut in pitch. It is placed in the firebox and screwed into place by means of a wrench fitting in the square hole in the outer head. The inner end can be riveted over, the same as with a solid stay-bolt, since the force of the blow is transmitted directly through to the outer end without lost motion. It has the further advantage of leaving a practically smooth outside sheet, to which the lagging, cab brackets and other boiler attachments can be applied with little difficulty.

The experiments so far made show that a deposit of hard scale will not prevent the action of this bolt, since its movement is always such as to force the scale away from the metal. If this feature proves itself after a long service, the greatest difficulty with flexible stay-bolts in bad water districts will be eliminated.

COMBINATION WET AND DRY GRINDER.

The combination wet and dry grinder, illustrated herewith, was designed for use in small shops, or in places where cramped for room and it is desired to do a variety of grinding on one machine. The dry grinder end is intended for grinding small pieces, castings or other rough work, and if desired may be arranged with a small surfacing table over the wheel for doing surface work. The wet grinding end is arranged for grinding tools.



COMBINATION WET AND DRY GRINDER.

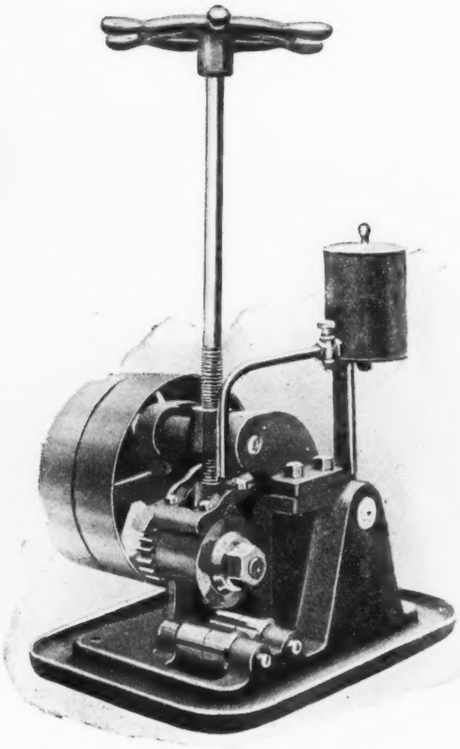
The bearings are ring oiling, of phosphor bronze, split, with removable sleeves. If the bearings become worn new sleeves can readily be applied. Each bearing has a large oil reservoir and an oil return from each end. Ring check nuts are used in connection with the dust collars at the end of each bearing, these check nuts being positive in their action in taking up end play.

The lower part of the base of the machine consists of a large air-tight water tank. Above this tank is another smaller one connected to it by a pipe, which extends from near the bottom of the lower tank to the normal water level in the upper one. In order to raise the water level in the upper tank to come in contact with the grinding wheel it is only necessary to give a few strokes to the air pump, thus forcing the air above the water in the lower tank, causing the water to flow to the upper one. Opening the small angle cock at the front of the machine allows that part of the water above the level of the top of the pipe to pass from the upper tank into the lower one. The sediment from the grinding settles to the bottom of the upper tank and may easily be removed when a new wheel is put in. As the connecting pipe extends almost to the bottom of the lower tank, and as this has a large storage capacity, one filling will last for a long time. To refill a tank it is only necessary to open the air cock and pour water into the bowl of the tool grinder until it begins to run out of the cock.

These machines are made in three sizes, carrying wheels 18, 20 and 26 ins. in diameter, by The Bridgeport Safety Emery Wheel Company, Inc., of Bridgeport, Conn.

NEW ROLLING PIPE CUTTER.

An improved rolling pipe and tube cutter has recently been designed by the Bignall & Keeler Mfg. Co. of Edwardsville, Ill., and is illustrated herewith. The driving shaft is connected to the cutter shaft by cut gears. The driving shaft is connected to by a screw working in a steel nut. The rollers are of large diameter and run on hardened steel pins. The cutter disc is made of the best tool steel carefully tempered and is stiffened by a pair of steel flanges. An oil tank and pan are furnished as shown. These machines are made in two sizes; No. 1 cutting from ¼ to 2 ins. and No. 2 from 1 to 4 ins.



NEW PIPE CUTTER.

THE TECHNICAL JOURNAL is a co-operative exchange. Its business is to tell the story, week by week or month by month, of current progress. Its pages are wide open to the man with a record of progress—real progress and not mere blowing of horns—if that record will be of practical service to the readers. The editor's function is like that of a baseball umpire—to say what is a hit and what is a foul and to endure with patience the objurgations of those who object to his decisions. —*Charles Whiting Baker, Editor Engineering News, at the dedication of the University of Pennsylvania Engineering Building.*

PERSONALS.

Mr. R. R. Douk has been appointed general foreman of the Wabash R. R. at Montpelier, Ohio.

Mr. George W. Miller has resigned as general foreman of shops of the Erie R. R. at Elmira, N. Y.

Mr. M. W. Fitzgerald has been appointed master mechanic of the Illinois Southern Ry., with office at Sparta, Ill.

Mr. Wm. Thornton has been appointed foreman of the car department of the Orange & Northwestern Ry., at Orange, Tex.

Mr. William Cormack of Stevens Point, Wis., for twenty years master car builder of the Wisconsin Central, is dead, aged 69.

Mr. James Fitzgerald, master mechanic of the Cleveland, Cincinnati, Chicago & St. Louis Ry. at Bellefontaine, Ohio, is dead.

Mr. W. H. Dempsey has been appointed mechanical engineer of the Atlanta, Birmingham & Atlantic Railroad Company at Fitzgerald, Ga.

Mr. F. A. Smock has been appointed master mechanic of the Pennsylvania R. R. at Meadows, N. J., to succeed Mr. J. W. Sanford, retired.

Mr. H. J. Trein has been appointed master mechanic of the Denver, Enid & Gulf Railway at Enid, Okla., to succeed Mr. John Rohrig.

Mr. R. F. Tyne, locomotive foreman at Brandon, Man., has been appointed master mechanic of the Canadian Pacific Ry. at Moose Jaw, Sask.

Mr. R. Griffith has been appointed master mechanic of the Colorado Midland Ry., at Colorado City, Colo., vice Mr. W. J. Schlacks, resigned.

Mr. Edward F. Fay has been appointed general foreman of the Omaha shops of the Union Pacific Railroad, succeeding Mr. Stovel, promoted.

Mr. H. Stovel has been appointed superintendent of shops of the Union Pacific Railroad at Omaha, Neb., succeeding Mr. A. W. Whiteford, resigned.

Mr. H. S. Wall has been transferred to Needles, Cal., as master mechanic of the Arizona division of the Atchison, Topeka & Santa Fe (Coast Lines).

Mr. T. R. Shanks has been appointed master mechanic of the East Broad Top Railroad, with office at Orbisonia, Pa., vice Edgar Shellaberger, deceased.

Mr. S. J. Ask has been appointed assistant road foreman of engines on the eastern division of the Lake Shore & Michigan Southern Ry. at Buffalo, N. Y.

Mr. J. W. Ruffner has been appointed master mechanic of the St. Louis Iron Mountain & Southern Ry. at Ferriday, La., in place of Mr. J. B. Tennant, resigned.

Mr. Walter Reid has been appointed road foreman of engines of the Arizona division of the Atchison, Topeka & Santa Fe (Coast Lines) at Needles, Cal.

Mr. E. J. Bouchard has been appointed superintendent of motive power and rolling stock of the Sierra Railway of California, with headquarters at Jamestown, Cal.

Mr. E. W. Woodhouse, district master mechanic of the Canadian Pacific Ry. at Moose Jaw, has been transferred to Calgary, Alta., vice Mr. John Cardwell, transferred.

Mr. David O. Shaver, formerly from March, 1867, to February, 1900, master mechanic of the shops of the Pennsylvania Railroad at Pittsburgh, Pa., is dead, aged 74 years.

Mr. M. P. Cheney, has been transferred to San Bernardino, Cal., as road foreman of engines of the Los Angeles division of the Atchison, Topeka & Santa Fe (Coast Lines).

Mr. Joseph Walker, of Paducah, Ky., has been appointed general foreman of the mechanical department of the Nashville & Evansville division of the Illinois Central R. R.

Mr. J. F. Enright, master mechanic of the Mobile & Ohio Railroad at Whistler, Ala., has been appointed to have jurisdiction also over the Southern Railway in Mississippi.

Mr. S. E. Thompson has been appointed assistant engineer of motive power of the Pennsylvania Railroad at Buffalo, N. Y.

Mr. Michael Malican has been appointed roundhouse superintendent of the New York Central Lines at East Buffalo, N. Y.

Mr. F. W. Malott, general foreman of shops at South Tacoma, has been appointed to succeed Mr. Crosby as superintendent of shops of the Northern Pacific Ry. at South Tacoma, Wash.

Mr. F. W. Mahl, master mechanic of the Southern Pacific Ry. at Sacramento, Cal., has resigned to accept a similar position with the Colorado & Southern Ry. with headquarters at Denver.

Mr. C. S. Kessler, foreman of car inspectors in the shops of the Pennsylvania Railroad at Sunbury, Pa., has been promoted to assistant to the general car inspector at Williamsport.

Mr. L. L. Young, acting master mechanic of the Detroit, Toledo & Ironton Ry. at Springfield, Ohio, is dead. Mr. Young had previously been traveling engineer and was promoted only one month ago.

Mr. James McQuillan, roundhouse foreman at Gainesville, Tex., has been appointed to succeed Mr. Robinson as division master mechanic of the Gulf, Colorado & Santa Fe Railway at Silsbee, Tex.

Mr. Thomas Malloy, master mechanic of the Albany & Hudson R. R., has resigned to become assistant superintendent of equipment on the Harlem division of the New York Central & Hudson River R. R.

Mr. W. A. George has been appointed master mechanic of the second and third districts of the Albuquerque division of the Atchison, Topeka & Santa Fe (Coast Lines), with headquarters at Winslow, Ariz.

Mr. J. B. Kilpatrick has been appointed superintendent of motive power of the Chicago, Rock Island & Pacific Ry., with office at Chicago, succeeding L. W. Harrison, acting superintendent of motive power.

Mr. M. Robinson, division master mechanic of the Gulf, Colorado & Santa Fe Railway at Silsbee, Tex., has been transferred to Temple, Tex., in a similar capacity, succeeding Mr. P. T. Dunlop, promoted.

Mr. George S. McKee, superintendent of motive power and car equipment of the Mobile & Ohio R. R., with office at Mobile, Ala., has had his jurisdiction extended over the Southern Railway Company in Mississippi.

Mr. R. M. Crosby, superintendent of shops of the Northern Pacific Ry. at South Tacoma, Wash., has been appointed general master mechanic of the Western division, with office at Tacoma, succeeding Mr. W. Moir.

Mr. A. J. Ball, master mechanic of the Toledo Railway & Terminal Company, Toledo, Ohio, has been appointed superintendent of motive power of the Detroit, Toledo & Ironton Ry., with headquarters at Jackson, Mich.

Mr. C. L. Acker, roundhouse foreman of the Baldwin Locomotive Works at Philadelphia, Pa., has been appointed master mechanic of the Toledo Railway & Terminal Company at Toledo, Ohio., succeeding Mr. A. J. Ball, resigned.

Mr. E. G. Haskins, heretofore acting master mechanic of the Denver & Rio Grande R. R. at Salida, Colo., has been appointed master mechanic of the Rio Grande Western Ry. at Salt Lake City, Utah, succeeding Mr. William Donald, resigned.

Mr. G. A. Gallagher has been appointed master mechanic of the Southern Indiana Ry., with headquarters at Bedford, Ind.

Mr. Robert D. Fidler, heretofore roundhouse foreman of the Chicago, Indianapolis & Louisville Ry. at Lafayette, Ind., has been appointed assistant master mechanic of the Cincinnati, Hamilton & Dayton Ry. at Indianapolis, Ind.

Mr. P. T. Dunlop, division master mechanic of the Atchison, Topeka & Santa Fe Ry. at Temple, Texas, has been promoted to mechanical superintendent, with headquarters at Cleburne, Texas. Mr. Dunlop suceeds Mr. A. Harrity, resigned.

Mr. M. J. Drury, master mechanic of the Atchison, Topeka & Santa Fe Ry. at Raton, N. M., has been appointed mechanical superintendent of the Western Grand Division, with headquarters at La Junta, Colo., succeeding Mr. C. M. Taylor, resigned.

Mr. A. W. Whiteford, heretofore superintendent of shops of the Union Pacific Railroad at Omaha, Neb., has been appointed shop superintendent of the Lehigh Valley Railroad with headquarters at Sayre, Pa., succeeding Mr. E. T. James, resigned.

Mr. R. D. Smith, formerly superintendent of motive power of the Chicago, Burlington & Quincy Ry., at Lincoln, Neb., has been appointed mechanical expert of the New York Central, in charge of special work on the lines west of Buffalo, reporting to Mr. J. F. Deems, general superintendent of motive power. Mr. Smith's appointment was effective October 1, and his office is at La Salle Street Station, Chicago.

BOOKS.

The *Mechanical World* Pocket Diary and Year Book for 1907. Pocket size, 4¼ x 6¼. 302 pages. Published by Emott & Company, Ltd., 65 King Street, Manchester, England. Price, sixpence.

This is the twentieth year of publication of this well-known pocket diary and year book, which is filled with useful engineering notes, rules, tables and data. It also contains about 60 blank pages with the dates for the year 1907, to be used as a diary or memoranda.

Text-Book on Geodesy and Least Squares. By Charles L. Crandall, Professor of Railroad Engineering and Geodesy, Cornell University. Published by John Wiley & Sons, New York, 1906. Price, $3.00.

This book is an outgrowth of a course of lectures prepared for instruction at Cornell at a time when there was but little available in English on the subject outside of the Coast Survey Reports. They were revised from time to time, and have now been elaborated and brought strictly up to the best standard practice and put into text-book form. The book is well illustrated and all parts of the subject are treated in a clear, concise manner.

The Steel Square as a Calculating Machine. By Albert Fair. 81 pages. Cloth, 5 x 7½. Published by the Industrial Publication Company, New York. Price, 50 cents.

This is an elementary work intended for the use of the comparatively uneducated workman or beginner. The matter is all simple, and shows how some very unexpected problems can be easily solved by the use of the ordinary steel square. Many of these would take tedious numerical work to perform, but can be quickly and easily solved by the methods shown. The entire work is simple and easily understood, and answers the purpose intended in a very satisfactory manner.

Proceedings of the American Railway Engineering and Maintenance of Way Association. Seventh annual convention, Chicago, 1906. Published by the Association. E. H. Fritch, Assistant Secretary, Chicago.

This volume, of 824 pages, contains the committee reports presented at the last convention, together with the discussion on them, list of members and mileage of roads represented, constitution and officers. The committee reports include those on ties, ballasting, yards and terminals, iron and steel structures; records, reports and accounts; classification of track; roadway; signs, fences, crossings and cattle-guards; signaling and interlocking, rails, masonry, buildings, track, water service and wooden bridges and trestles.

Proceedings of the Master Car Builders' Association. Fortieth annual convention, Atlantic City, June, 1906. Published by the Association, J. W. Taylor, Secretary, 390 Old Colony Building, Chicago.

In addition to the complete committee reports, discussion of the reports, and topical discussions, this volume contains the revised rules and corrected standards and recommended practice of the association.

Turning and Boring Tapers. By Fred H. Colvin. Paper bound. 25 pages. Published by the Derry-Collard Company, New York. Price, 25 cents.

This is the first of a series of practical papers which are being published by this company, and is the second edition of the one on turning and boring tapers. It is clearly illustrated by line drawings, and shows the proper method of turning or boring tapers on a lathe, both with and without attachments. This includes straight and compound tapers, as well as tapered threads. A chapter is also included on turning tapers on boring mills. The matter is given in a clear and concise manner, and forms a valuable pamphlet for the use of shop foremen and machinists.

Proceedings of the American Railway Master Mechanics' Association. Thirty-ninth annual convention, Atlantic City, June, 1906. Published by the Association, J. W. Taylor, Secretary, 390 Old Colony Building, Chicago.

This volume contains the complete reports and discussion thereon of all the committees reporting at the last convention, which included those relating to locomotive front ends, flexible stay-bolts, wheel center design, classification of locomotive repairs, specifications for cylinder iron and electricity on steam roads, as well as individual papers on special valve gears, superheated steam and locomotive injectors. The excellent address of President H. F. Ball is given complete, and the volume also contains the standards and specifications of the association.

American Stationary Engineering. Facts, rules, and general information for the stationary engineer. By Mr. W. E. Crane. 285 pages, cloth. Published by the Derry-Dollard Company, New York. Price, $2.00.

This volume is intended for the managers and superintendents of power plants as well as the enginemen and firemen. It contains full directions for the care of stationary boilers, pumps and engines. A chapter is given on the repairs of stationary engines and pumps, which are all clearly illustrated by sketches. Other chapters deal with air pumps and condensers, belts, lubrication, chimneys, steam heating, piping, etc. A list of examination questions gives an idea of the features upon which the stationary engineer should be well informed.

Railroad Signal Association—Digest of Proceedings. Two volumes. Compiled under the direction of the executive committee. H. S. Balliet, Secretary, Grand Central Station, New York. Published by the Times Publishing Co., Bethlehem, Pa.

For the purpose of making the papers, reports and discussions of the Railway Signal Club and the Railway Signal Association more readily accessible for reference it was decided at the 1904 annual meeting to republish them, and these two cloth-bound volumes have now been completed. They contain a full report of all the meetings of the association since its birth, on March 11, 1895. The subjects have been arranged for easy reference, and Vol. II contains an index for both volumes. A list of members, corrected to August 24, 1906, and the revised constitution, adopted May 8, 1906, are included.

Air Compressors and Blowing Engines. By Chas. H. Innes, M. A. Published by D. Van Nostrand Company, New York. Price, $2.00.

As stated in the preface, this book deals with the construction of blowing engines and air compressors, and is reprinted from a series of articles which originally appeared in *The Practical Engineer*. The first chapter discusses the properties of air, and shows how to calculate the work required for compression under various circumstances. The second describes several experiments with compressors and explains the methods of calculating the various efficiencies. The third deals with the theory of valves for equalization of pressure, and the fourth is devoted to the construction of blowing engines. Chapter V commences the description of air compressors. These have self-acting valves, and the remainder of the book is devoted to those with mechanically controlled valves. The book is well illustrated.

Poor's Manual of Railroads, 1906, thirty-ninth annual number. Published by Poor's Railroad Manual Company, 68 William Street, New York. Price, $10.

The scope and size of this edition of the well-known Poor's Manual has been enlarged by the addition of several important features, previously published separately in "The Railroad Manual Appendix." These include all the data embraced in Poor's Ready Reference Bond List, as well as tables of annual meetings, transfer agencies, etc., and tables of dividends paid for eight years. These additions, in connection with the natural growth of the other matter and the insertion of more maps and an improved index, make this a volume of 1,800 pages. Many new industrial corporations have been included, as well as newly incorporated steam and electric railroads.

Marine Engineers: Their Qualifications and Duties. By E. G. Constantine, Assoc. M. Inst., C. E., M. I. Mech. E. Second edition. Published by D. Van Nostrand Company, New York. Price, $2.00.

The object of the author is to furnish information to various classes of readers, including parents and guardians who may have some idea of placing their sons in the way of becoming marine engineers; boys who aspire to become marine engineers; youths who are serving their apprenticeship either in land or marine engineering works, as well as those who are working as journeymen, but wish to go to sea; and young engineers who have made a start at sea. Obscure technicalities have been carefully avoided, and first principles have only been sufficiently touched on to indicate the course which, in the writer's opinion, is best calculated to secure the acquisition of that knowledge of the science of engineering and cognate branches which are the essential charactristics of the engineer.

Text Book on the Strength of Materials. By S. E. Slocum, assistant professor, University of Illinois, and E. L. Hancock, instructor at Purdue University. Cloth, 7 x 9½. 314 pages. Illustrated. Published by Ginn & Company, Boston. Price, $2.00.

The aim of the authors of this book has been to produce a text book of the best modern theory and practice and at the same time sufficiently elementary for the use of students of the junior grades in technical and engineering schools. The book has been divided into two parts, the first presenting the theoretical side of the subject and the second the experimenal side. The former is for use in the class room and the latter for a laboratory manual, and each important point is illustrated by a practical application. The exercises chosen for this purpose being for computation in Part I. and for observation in Part II. Some important features of this book are the definition of the moment of inertia as the shape factor in the mechanics of materials; graphical method of calculating centers of gravity and moments of inertia; application of the principle of least work; comparison of column formulas; accurate formulas for the torsion of shafts; simple methods of calculating the strength of curved pieces, and also a separate chapter on the modern use of reinforced concrete.

Locomotive Dictionary. An Illustrated Vocabulary of Terms Which Designate American Locomotives, Their Details of Construction, With Definitions of Typical British Locomotive Practice. First edition compiled for the American Railway Master Mechanics' Association, by Geo. L. Fowler; 623 pp. Published by *The Railroad Gazette*, New York. Price, $6.00.

In general arrangement the new Locomotive Dictionary follows the scheme of the last edition of the Car Builders' Dictionary, and consists of about 100 pages of definitions, followed by 523 pages of illustrations and drawings, both general and detailed, of modern American and British locomotives. Reference to figure numbers in the definitions and a carefully followed up system of numbered parts in both drawings and definitions makes the determination of the proper name or the location of any part rapid and accurate. In addition to this complete matter on both steam and electric locomotives, there are sections on locomotive appliances of all kinds and many modern machine tools for locomotive repair shops.

This volume will be found to be of great value for reference in railroad drafting rooms and motive power offices, and, even considered as a treatise illustrating modern locomotive design, it is by far the best work published in several years. In view of the fact that the first action of the Master Mechanics' Association, which has resulted in this work, was taken in June, 1905, the promptness with which it has been completed is to be most heartily commended.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

CRANDALL PACKINGS.—An attractive new catalog and price list is being issued by the Crandall Packing Company, Palmyra, N. Y It contains illustrations showing the appearance and structure, accompanied by brief notes explaininig the special service for which each kind is adapted; of packings for all conditions of service on machines working steam, ammonia or hydraulic pressures. Sheet packings and gaskets of many different grades are included. This company carries a line of leather and rubber beltings as well as steam and water hose, which are also shown in the catalog.

ELECTRIC CRANES.—The Case Manufacturing Company, Columbus, Ohio, is issuing bulletin No. 22, in which are a large number of half-tone illustrations, accompanied by clear descriptive matter, showing the many improvements which have recently been made in the cranes manufactured by this company. Each detailed part of the crane is shown and considered separately. Special mention is made of the fact that cranes to be operated by alternating current can now be obtained which will give perfect satisfaction. This company manufactures cranes of all sizes and for all purposes.

GRAPHITE AS A LUBRICANT.—The tenth edition of "Graphite as a Lubricant" has just been printed, and is now being distributed by the Joseph Dixon Crucible Company. The subject of lubrication in general, and graphite lubrication in particular, is exhaustively treated. All the good features of the previous edition are retained, but the very latest information—both scientific and practical—that has to do with the subject is added, making it valuable to the student of theory and the man of practice. The publication is arranged and indexed so as to readily enable the reader to find the information he is most interested in.

FRANKLIN AIR COMPRESSORS.—The Chicago Pneumatic Tool Company, Fisher Building, Chicago, Ill., is issuing catalog No. 20, which is devoted exclusively to a detailed description of the Franklin air compressor. It is a book of 116 pages, containing illustrations with full detailed descriptive list of over 100 sizes and styles of this type of compressor. Several new designs, including the Corliss, motor-driven, gas engine driven and new large capacity patterns are shown. Considerable space is devoted to the subject of pumping by compressed air and the new Chicago Water Lift is described. A number of valuable tables and formulas are included.

SIGNAL TOWER OIL OUTFIT.—S. F. Bowser & Company, Fort Wayne, Ind., is issuing bulletin No. 57, which illustrates and describes the Bowser system of oil supply for use in signal towers. This arrangement places the pump in the tower and the tank in the ground. The apparatus complete is of the well-known design at present in use in the oil houses of many of the larger railway systems. In this case the tank is buried in the ground on the opposite side of the track from the tower, and the pump, which is of the self-measuring design, is placed at any convenient point in the tower.

THE DRAFT GEAR PROBLEM.—The Frost Railway Supply Company, Detroit, is issuing a pamphlet which contains reprints of two excellent papers recently presented on the draft gear problem. The first one is titled "Friction Draft Gear on Cars and Locomotives," and was presented at the May meeting of the Central Railway Club by Mr. W. O. Thompson, New York Central Lines. This is followed by Mr. A. Stucki's article on "Functions of a Good Draft Gear," which appeared in the *Railroad Gazette* of February 23, 1906. Comments by the Frost Company are given in red marginal notes, which call attention to the most vital features mentioned in the papers.

AIR HAMMER DRILLS AND AIR MOTOR HOISTS.—Bulletins on these two subjects are being issued by the Ingersoll-Rand Company, Pneumatic Tool Department, 11 Broadway, New York. The "Little Jap" hammer drill, with which one of the bulletins deals, has proved itself to be most valuable and is becoming almost indispensable for lighter work in rock excavations. The details of its construction and operation under different conditions are shown. The second pamphlet treats in a similar manner the "Imperial" motor hoists and stationary motors. It contains a complete description of the motor hoists, with tables of sizes and dimensions, and also the "Imperial" stationary motor, which fills the demand for a motor of small power for intermittent service.

RECORD OF RECENT CONSTRUCTION.—The Baldwin Locomotive Works, Philadelphia, is issuing the latest "Record of Recent Construction," which is numbered 59 and includes the usual illustrations and complete dimensions of a large number of freight and passenger locomotives of different types recently built at their works for American railroads.

JEFFREY PULVERIZERS.—The Jeffrey Manufacturing Company, Columbus, Ohio, is issuing catalog No. 31, which deals with crushing and pulverizing machinery. The catalog is very completely illustrated and shows several different designs of crushers and pulverizers manufactured. Each important detail, feature or part is illustrated and described separately, and machines of a number of different types and sizes are shown, tables being included for exact dimensions. These pulverizers are intended for use with coal, coke, ores, lime-stone, brick, bone, etc.

CONSOLIDATION TYPE FREIGHT LOCOMOTIVE.—A pamphlet just published by the American Locomotive Company illustrates and describes consolidation locomotives weighing more than 175,000 lbs. It is a sequel to the pamphlet issued in October presenting designs of this type weighing less than 175,000 lbs. In the pamphlet 28 consolidation locomotives built for various railroads, and ranging in weight from 175,000 lbs. to 250,000 lbs., are illustrated, and the principal dimensions of each design are given. This is the fourth of the series of pamphlets which is being issued by the American Locomotive Company to include all the standard types of locomotives. The series now covers the Atlantic, Pacific and consolidation types. Copies of these pamphlets may be had upon request.

STEAM ENGINES AND ELECTRIC HOISTS.—The Allis-Chalmers Company, Milwaukee, Wis., is issuing bulletins Nos. 1506 and 1510, which are arranged to be bound in their loose-leaf binder. The former of these is on electric hoists, which are built complete by this company in single drums from 15 to 75 h.p. and in double drums from 30 to 150 h.p. The bulletin gives a complete description of all the different features of the hoists and contains tables showing dimensions, speeds, capacities, etc. Bulletin No. 1510 illustrates and describes the direct connected Reynolds Corliss engines of the heavy duty pattern. These engines are furnished in both simple and compound, horizontal, vertical or combined horizontal and vertical. One page is devoted to a list of the information required by the company in making estimates of sizes and prices.

ELECTRIC SUPPLIES FOR RAILWAYS.—The General Electric Company is issuing a 233-page cloth bound catalog, which, it is stated, has been issued for the purpose of placing in the hands of its customers information which will enable them to readily select repair parts for the maintenance of equipment and lines, and for such other supplies as are best suited to the various requirements in the construction and operation of complete electric railway systems. The various classes of material are arranged to facilitate the selection of repair parts most often required, and each section includes descriptive matter sufficient for the customer to readily determine the exact material necessary for his particular needs. The catalog is very complete, and includes practically all apparatus used on electric railways. The same company is also issuing bulletins Nos. 4,465 and 4,467. The former on trolley frogs, their proper selection and location for different service, and the latter on the emergency straight air brake system.

NOTES.

FARLOW DRAFT GEAR COMPANY.—About December 1 the Chicago office of this company will be moved from the present quarters in the Monadnock Building to 1713 Fisher Building.

GRIP NUT COMPANY.—This company is now represented in New York by Mr. T. F. DeGarmo, whose office is at 500 Fifth Avenue. The main office of the company is at 152 Lake Street, Chicago, Ill.

CRANDALL PACKING CO.—Owing to increased business, which requires larger space, the Cleveland office of this company has been moved from 9 South Water Street to 805 Superior Street, N. W.

CHICAGO PNEUMATIC TOOL COMPANY.—Mr. J. W. Duntley, president of the Chicago Pneumatic Tool Company, sailed for Europe on November 6th for a five weeks' trip in the interest of the company's business, during which time he will visit the important trades generally in England, Scotland, France and Germany.

THE DAYTON PNEUMATIC TOOL COMPANY.—This company is sending souvenir telescopic lead pencils to its friends.

FAIRBANKS, MORSE & CO.—Mr. Albert A. Taylor, who for the past eight years has been a traveling representative for Fairbanks, Morse & Company, has been appointed manager of the railroad department of that company, with headquarters in Chicago. He supercedes Mr. W. H. Garrett.

CROCKER-WHEELER COMPANY.—This company is now installing a 300-k.w. alternating current generator in the Kingsland repair shops of the Delaware, Lackawanna & Western Railroad. Two similar machines have been working for a little over a year with entire success. This third machine has been installed to furnish the increased demand for power.

ADVANCING PRICES OF ELECTRICAL APPARATUS.—It is announced that because prices in the electrical trade continue to show a distinct upward tendency in sympathy with the well-maintained advance which has taken place in the prices of all raw materials, orders for future delivery can now in many instances only be placed at a considerable advance over present market quotations. The General Electric Company, in common with many other large manufacturing concerns, is announcing a general advance in prices of electrical apparatus and supplies, which action will not unlikely be followed by further advances if present market conditions continue.

COMMONWEALTH STEEL COMPANY.—The controlling interest in this company has been purchased by Mr. Clarence H. Howard from the American Steel Foundries, which now holds no interest whatever in the company. The plant of the company, which has a capacity of about 3,000 tons per month, is located at Granite City, Ill. The newly elected officers are as follows: Clarence H. Howard, president; Thomas K. Niedringhaus, vice-president; Harry M. Pflager, vice-president; George K. Hoblitzelle, vice-president and treasurer; Frank L. Morey, secretary and auditor; George E. Howard, vice-president and sales agent; Arthur T. Morey, assistant to the president and general attorney; W. E. Hoblitzelle has been appointed general manager; Charles T. Westlake, general mechanical engineer; C. F. Frede, mechanical engineer, and R. A. Bull, general superintendent.

THE ARNOLD COMPANY.—The locomotive shop of the Grand Trunk Railway at Battle Creek includes the machine and erecting, boiler and tank shops under one roof, the building being 170 by 817 ft., and containing 25 erecting pits, 9 boiler stalls and 9 tank stalls. The foundation work on this building is started. Other buildings of the locomotive department will follow shortly, as the intention is to have this department ready for operation before the end of 1907. Bids have been received for the boiler and forge shop of the Big Four at Indianapolis, and the contract will be let shortly. Work on the power house, tank shop and the storehouse is being pushed rapidly. The Kansas City Southern Railway shops at Pittsburg, Kan., roundhouse and power house, coaling pocket, cinder pits and sand house are nearing completion. The complete improvements in addition will include a new 16-pit machine and erecting shop, 30-ton yard crane, transfer table and reinforced concrete oil house.

NEW STEEL CAR PLANT.—The Standard Steel Car Company, Frick Building, Pittsburgh, with main works at Butler, Pa., recently bought 380 acres of land at Hammond, Ind., on which it will erect a very large plant for the manufacture of steel cars. The plant originally will have five main buildings, contract for which has been placed with the McClintic-Marshall Construction Company, Pittsburgh, and which will require about 4,000 tons of steel. The steel car shop will be contained in a steel building about 1,600 ft. long and 300 ft. wide, while the wooden car shop will also be contained in a steel building 1,600 ft. long and about 200 ft. wide. The truck shop, paint shop and car house will each be contained in separate steel buildings, ranging in size from 500 to 800 ft. long. The new plant will have a capacity for turning out about 60 steel and composite cars per day, the latter being wooden cars with steel underframe. This new plant is expected to be ready for operation about August 1, 1907. The works of this company at Butler, Pa., have been greatly enlarged in the past two or three years, and are now turning out from 90 to 100 steel cars per day, so that when the new plant at Hammond is finished and in operation the Standard Steel Car Company will have a capacity for making from 150 to 160 steel cars per day.